ELECTRIC AND MAGNETIC FIELD EVALUATION
FOR
PROPOSED BORDERTOWN TO CALIFORNIA
120 kV TRANSMISSION LINE

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NOTICE

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Section 1. Approach and Methodology

NV Energy is proposing to construct a new transmission line in the area near Reno, Nevada. This new facility, named the "Bordertown to California Transmission Line" (also called the "C2B" line), would be approximately 10 miles long and electrically connect the existing Bordertown and California Substations. The proposed transmission line would be energized at 120,000 volts (120 kV) and supported on wooden poles. This line would be routed either by itself within a right-of-way easement or be co-located near other existing transmission lines. Figure 1 presents a diagram of the proposed transmission line route, along with other alternative routes.

This report section discusses some basic electric and magnetic field (EMF) principles and then presents the EMF measurement protocol, site measurement results, computer modeling assumptions, associated calculated field levels for the proposed project, and an overview of EMF-related health studies and potential impacts.

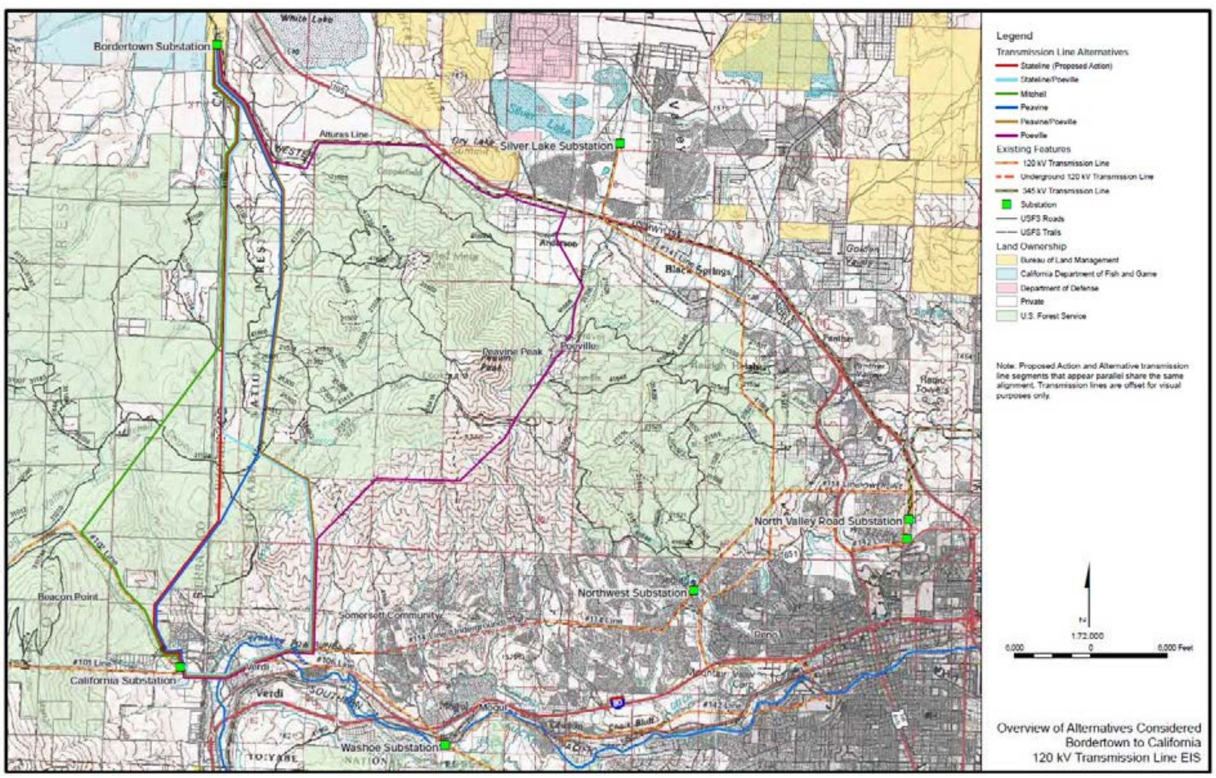


Figure 1
Preferred and Alternative Routes for Proposed Bordertown to California (C2B) Transmission Line

The Electric Power Transmission and Distribution System

The transfer of electric power from an electrical generation site to the end user features a transmission system (for bulk transfer of electrical power) and a distribution system (for delivery of local electricity to end users such as industries and residences). Power lines are interconnected with other power lines at substations, which allow for switching power among lines and connecting lines at different voltages. Substation transformers can lower the voltage from a transmission line level (such as 120 kV) to a distribution level (such as 25 kV). Other transformers placed close to the end user provide the household electrical power commonly used for appliances and machinery. The project line would be a 120 kV transmission line which would transfer electrical power from one substation to another substation (between Bordertown and California substations).

Electric transmission and distribution lines carry alternating current (AC) which reverses direction at a frequency of 60 cycles per second (60 hertz or 60 Hz) in the United States; in many other countries, this frequency is 50 Hz. Electric and magnetic fields (EMF) produced by the AC voltage and current therefore are also 60 Hz AC fields. These fields are sometimes improperly conflated with fields associated with radio, TV, cellular telephones and many communication systems which operate at much higher frequencies, from approximately 500,000 Hz (500 kHz) to over 2,000,000,000 Hz (2 GHz). At these higher frequencies (often called radiofrequencies), electric and magnetic fields mutually form an electromagnetic field that can carry energy through space. Radiofrequency electric and magnetic fields cannot be studied separately, but must be treated as a mutually related pair, “the electromagnetic field.” Confusingly, this energy field is also abbreviated “EMF,” but should not be confused with the EMF fields associated with 60 Hz transmission and distribution lines, particularly because the physical actions on the body of radiofrequency fields are wholly different from the actions of electric and magnetic fields at 50 or 60 Hz.

Power lines used for transmission and distribution each produce EMFs, although field strengths differ according to the currents, configurations of the wires on poles or towers, and different distances away from the power line wires.

Description of Power-Frequency Electric and Magnetic Fields

Electric Fields

The potential or voltage (electrical pressure) on an object creates an electric field. Any object with an unbalanced number of electric charges on it has a voltage (potential) at its surface as compared with another object or surface. In electricity, electrons carry the charge on and in conducting objects. In a symmetrical manner, objects with a deficit of electric charge (that is, too few electrons for charge balance) also have a voltage (potential) as compared with another object. The effect arising from unbalanced electric charges is not limited to the surface voltage of the object but exists in the space surrounding the object with diminishing intensity at greater distances. This effect is called the electric field, which can exert a force on other electric charges at a distance from the object. The change in voltage in space over distance is a measure of electric field strength. The units describing an electric field are volts per meter (V/m) or kilovolts per meter (kV/m). These units are measures of the difference in electrical potential or voltage that exists between two points about 3 feet apart. The electric field becomes stronger near a charged object and decreases with distance away from the object.

Electric fields are very common phenomena. Static electric fields can result from friction generated when taking off a sweater, sliding across a car seat, or walking across a carpet. Body voltages as high as 16,000 volts have been measured to result from walking on a carpet (Chakravarti and Pontrelli 1976). The earth creates a natural static electric field in fair weather that is a result of the 300,000 to 400,000 volt potential difference between the ionosphere and the surface of the earth (Veimeister 1972). At ground level the average value of the earth's electric field is approximately 120 V/m. This means that a 6-foot tall person would have a static potential of about 220 volts between the top and bottom of their body.

The fair weather static electric field of the earth varies from month to month, reaching a maximum of about 20 percent above average in January, when the earth is closest to the sun, and falling to about 20 percent below average by July, when the earth is farthest from the sun. Much stronger static electric potentials can exist underneath storm clouds, where the electric potential of clouds (with respect to earth) can reach 10 to 100 million volts (Veimeister 1972). Natural static electric fields under clouds and in dust storms can reach 3 to 10 kV/m (CRC 1981).

All household appliances and other devices that operate on electricity create electric fields. However, these fields are different from the earth's static or direct current (DC) field and some comparisons between DC and AC fields may not be appropriate. Fields produced by electrical appliances that use alternating current (AC) reverse direction at a frequency of 60 cycles per second (60 Hertz) in the United States. The electric field in this case is caused by the alternating electric voltage supplied to the appliance. The magnitude of the electric field decreases rapidly with distance from the device. The field caused by household appliances generally attenuates more rapidly with distance than fields generated from power lines. Appliances need not be in operation to create an electric field; just plugging an appliance into an electrical outlet creates an electric field around it. Typical values of electric field measured 1-foot away from some common appliances are shown in Table 1 (Carstensen 1985; Enertech Consultants 1985).

Table 1. Typical Electric Field Values for Appliances, at 12 Inches

Appliance	Electric Field (kV/m)
Electric Blanket	0.25*
Broiler	0.13
Refrigerator	0.06
Iron	0.06
Hand Mixer	0.05
Coffee Pot	0.03

*** *Note:* 1 to 10 kV/m next to blanket wires**

Source: Carstensen 1985; Enertech Consultants 1985

Transmission Line Electric Fields

Transmission line electric fields result from the voltage of the transmission line conductors with respect to the ground. The electric field is a vector quantity having magnitude and direction.

Electric field strengths from a transmission line decrease with distance away from the outermost conductor, typically at a rate of approximately one divided by the distance squared ($1/d^2$). As an example, in an unperturbed field, if the electric field strength is 10 kV/m at a distance of 1 meter away, it will be approximately 2.5 kV/m at 2 meters away, and 0.625 kV/m at 4 meters away. In contrast, the electric field strength from a single conductor typically decreases at a rate of approximately one divided by the distance (1/d). As an example, an electric field strength of 10 kV/m at 1 meter away would decrease to approximately 5 kV/m at 2 meters away, and 2.5 kV/m at 4 meters away. Electric field strengths for a transmission line remain relatively constant over time because the voltage of the line is kept within bounds of about ±5 percent of its rated voltage.

High voltage AC power lines have a set of three conductors in order to utilize the greater efficiency possible with generation and transmission of three-phase power in which the alternating voltage and current on any one wire is out of step by one-third cycle (1/180 of a second or 0.0056 second) compared to the other two. When near an overhead three-phase power line, the electric field from each conductor can be distinguished with instruments that measure the electric field strength, but at a distance the three lines merge to appear as if there is a single source of a three-phase electric field.

Transmission line electric fields are affected by the presence of grounded and conductive objects (Figure 2). Trees and buildings, for example, can significantly reduce ground level electric fields by shielding the nearby area (Deno and Silva 1987).

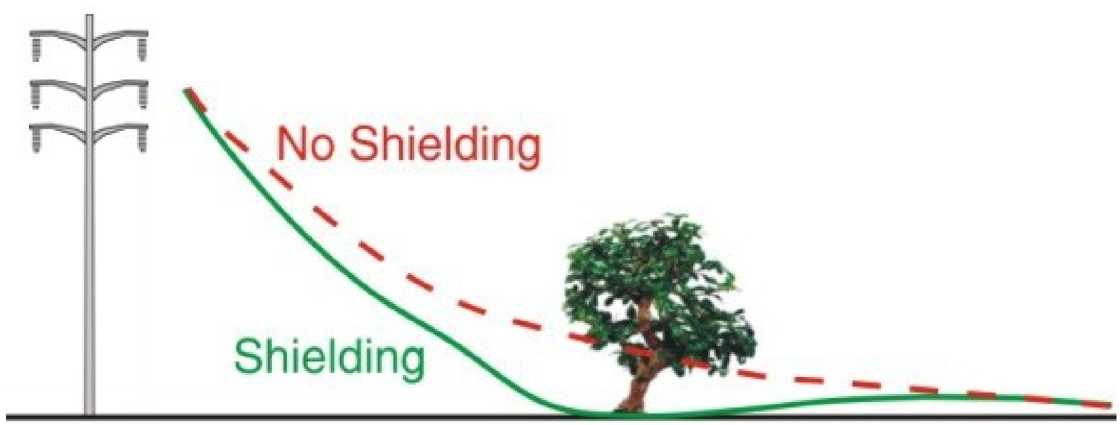


Figure 2
Electric Field Measurements Demonstrate Shielding Due to the Presence of a Tree

Magnetic Fields

An electric current flowing in a conductor (electric equipment, household appliance, power circuits, etc.) creates a magnetic field. The most commonly used magnetic field intensity unit of measure is the gauss (G). For most practical applications, the gauss is too large, so a much smaller unit, the milligauss (mG), is used for reporting magnetic field magnitudes. The milligauss is one thousandth of a gauss.

As a general reference, the earth has a natural static or direct current (DC) magnetic field of about 0.540 gauss, or 540 mG, in the Reno, Nevada (Merrill 1983). As with electric fields, the magnetic fields from electric power facilities and appliances differ from static (or DC) fields because they are caused by the flow of 60 Hz alternating currents. Power frequency magnetic fields reverse direction at a rate of 60 cycles per second corresponding to the 60 Hz operating frequency of power systems in the United States.

Since the magnetic field is caused by the flow of an electric current, a device must be operated to create a magnetic field. Magnetic field strengths of a large number of common household appliances were measured by the Illinois Institute of Technology Research (IITRI 1984) for the U.S. Navy (Gauger 1985), and by Enertech Consultants for the Electric Power Research Institute (EPRI) (Silva et al. 1989). Typical magnetic field values for some appliances have been measured as low as 0.3 mG to as high as 20,000 mG (Table 2). The appliances listed in Table 2 operate on 60 Hz AC and produce power-frequency AC magnetic fields (as opposed to other devices, such as Magnetic Resonance Imaging [MRI] machines which utilize DC magnetic fields or Computer Tomography [CT] scanners which utilize high frequency X-rays).

There are many sources of magnetic fields encountered in everyday activities. Two major research projects have been conducted to evaluate public exposure to ambient 60 Hz magnetic fields. This work was done to identify typical levels encountered by people inside homes and elsewhere. In the first study, a large number of residences located throughout the United States were measured to determine the sources and characteristics of residential magnetic fields (Enertech 1993). This project is called the “Thousand Home Study”. During this study, spot (point-in-time) magnetic field measurements were taken in the rooms of almost 1,000 residences (Table 3). The average measured value for all rooms in this study was 0.9 mG.

Another comprehensive study (the “Thousand Person Study”) of contemporary magnetic field personal exposure was performed for the U.S. Department of Energy (Enertech 1998). The objective of this work was to characterize personal magnetic field exposure of the general population. This study was accomplished by randomly selecting over 1,000 people located throughout the United States and recruiting these people to wear a recording magnetic field meter during a typical 24-hour period, including all activity inside and away from the place of residence (Silva 1999). The study population was selected in a manner to be representative of the general population. The measurement population (both genders) included about 874 adults and 138 children. People can experience a wide range of magnetic field exposures and sources. The U.S. 24-hour average for all people in this study was 1.25 mG. Most of the population was exposed to less than 1 mG (Table 4). Exposure levels also varied by occupation (Table 5).

Table 2. Magnetic Fields from Household Appliances

Appliance	Magnetic Field at 12 inches Away (mG)	Maximum Magnetic Field (mG)
Electric Range	3 to 30	100 to 1,200
Electric Oven	2 to 25	10 to 50
Garbage Disposal	10 to 20	850 to 1,250
Refrigerator	0.3 to 3	4 to 15
Clothes Washer	2 to 30	10 to 400
Clothes Dryer	1 to 3	3 to 80
Coffee Maker	0.8 to 1	15 to 250
Crock Pot	0.8 to 1	15 to 80
Can Opener	35 to 250	10,000 to 20,000
Microwave Oven[1]	3 to 40	65 to 812
Blender, Popper, Processor	6 to 20	250 to 1,050
Vacuum Cleaner	20 to 200	2,000 to 8,000
Portable Heater	1 to 40	100 to 1,100
Fans/Blowers	0.4 to 40	20 to 300
Hair Dryer	1 to 70	60 to 20,000
Electric Shaver	1 to 100	150 to 15,000
Fluorescent Light Fixture	2 to 40	140 to 2,000
Fluorescent Desk Lamp	6 to 20	400 to 3,500
Circular Saws	10 to 250	2,000 to 10,000
Electric Drill	25 to 35	4,000 to 8,000

Source: IITRI 1984; Silva 1989

Table 3. Summary of Spot Room Measurements in the United States (992 Residences) - mG

Values Exceeded in:	All Rooms Median Average		Kitchen	Bedroom(s)	Highest Room *
50% of Residences	0.5	0.6	0.7	0.5	1.1
25% of Residences	1.0	1.1	1.2	1.0	2.1
10% of Residences	1.7	2.1	2.4	2.0	3.8
5% of Residences	2.6	3.0	3.5	2.9	5.6
1% of Residences	5.8	6.6	6.4	7.7	12.2

*** *NOTE* - Any room in which spot field measurement had the highest value**
Source: Enertech 1993

[1] Microwave ovens produce power-frequency (60-Hertz) fields as well as the microwave energy inside of the appliance which is at a much higher frequency. Higher frequency fields are shielded internally but the power-frequency fields are not.

Table 4. Percentage of U.S. Population with Average Field Exposure Exceeding Given Values (Based on 1998 population of 267 million)

Average 24-Hour Field	Est. Portion	95% Confidence Interval	Population Range
> 0.5 mG	76.3%	73.8 % - 78.9 %	197 - 211 million
> 1 mG	43.6%	41 % - 46.5 %	109 - 124 million
> 2 mG	14.3%	11.9 % - 17.2 %	31.8 - 45.9 million
> 3 mG	6.3%	4.8 % - 8.3 %	12.8 - 22.2 million
> 4 mG	3.35%	2.4 % - 4.7 %	6.4 - 12.5 million
> 5 mG	2.42%	1.67 % - 3.52 %	4.5 - 9.4 million
> 10 mG	0.43%	0.21 % - 0.90 %	0.56 - 2.4 million
> 15 mG	0.1%	0.02 % - 0.55 %	50 thousand - 1.5 million

Source: Enertech 1998; Silva 1999

Table 5. Average Magnetic Field Exposure During Work for Different Occupations

Occupation	n	Average Magnetic Field at Work
Managerial, professional, specialty	204	1.64 mG
Technical, sales, administrative, support	166	1.58 mG
Service: Protective, food, health, cleaning	71	2.74 mG
Farming, forestry, fishing	19	0.91 mG
Precision production, craft, repair, operators, fabricators, laborers	128	1.73 mG
Electrical	16	2.15 mG

Source: Enertech 1998; Silva 1999

Transmission Line Magnetic Fields

Electric power transmission lines also create magnetic fields. These fields are generated by the current (amperes) flowing on the phase conductors. The magnetic field is a vector quantity having magnitude and direction. The magnetic field encircles the wire and the direction of the magnetic field is dependent upon the direction of current flow.

As is the case with an electric field, magnetic field strength attenuates rapidly with distance, occurs with phases determined by the phase of the individual line currents, and falls off in strength with the square of distance from the power line. Unlike electric fields, magnetic fields are not shielded by most objects or materials, including the human body. Unlike electric fields that vary little over spans of several seconds or longer (hours), magnetic fields are not constant over time because the current on a power line changes in response to increases and decreases in the electrical load, although bulk power transmission lines tend to be more stable.

Electric and Magnetic Field Assessment Methodology

The primary factors affecting electric and magnetic field intensity at any point are: voltage/current on the conductors, line configuration (conductor arrangement and phasing), and distance from the conductors. The electric and/or magnetic field from an electric power transmission line can be measured using special instruments and techniques. It can also be calculated with computer software. In situations where a transmission line is proposed to be constructed, electric and magnetic field values are typically calculated using computer modeling because no line exists to measure. These computer programs allow the transmission line configuration information and other parameters to be entered into the program to create a model of the proposed line. The software then calculates the 60 Hz electric and magnetic field at locations of interest.

For this study, assessment of electric and magnetic fields was performed in a two-fold manner: 1) utilizing site measurements at selected route locations to characterize existing electric and magnetic field strengths from existing electrical facilities, and 2) performing computer modeling to calculate field levels for the project transmission line in combination with existing adjacent transmission and distribution lines for light, medium, and maximum loads.

Section 2. Applicable Laws, Regulations, and Standards

Health-Based Standards for EMF

Presently, due to a lack of scientific evidence establishing adverse health effects resulting from exposure to power-frequency electric and magnetic fields found in environments accessible to the public, there are no federal health-based standards for limiting exposure to those fields. Consequently, electric and magnetic fields are not environmental impacts as defined in federal law by the National Environmental Policy Act (NEPA). However, science-based exposure limits have been established or recommended by several non-governmental organizations. These exposure limits address both electrical field and magnetic field exposure, and in some cases provide exposure limits for the special circumstance of workers with implanted medical devices.

The "Threshold Limit Values" published by the American Conference of Governmental Industrial Hygienists (ACGIH 2012), recommend that occupational exposures should not exceed 25 kV/m for AC electric fields and 10,000 mG for AC magnetic fields. Above 15 kV/m, the ACGIH recommends the use of protective clothing. For workers with cardiac pacemakers, recommended exposures should not exceed 1 kV/m for AC electric fields and 1,000 mG for AC magnetic fields. Table 6 presents a summary of the ACGIH guidelines for AC electric and magnetic fields. Some implanted medical device manufacturers have also reported recommendations for their equipment which are comparable to the ACGIH limits for magnetic fields and higher limits for electric fields (for example, 6 kV/m for 60 Hz electric fields and 1 gauss for 60 Hz magnetic fields).

Table 6. ACGIH – Occupational Threshold Limit for 60-Hertz Electric and Magnetic Field Exposure

Exposure	AC Electric Field	AC Magnetic Field
Occupational exposures should not exceed	25 kV/m (from 0 Hz to 100 Hz)	10 gauss (10,000 mG)
For workers with cardiac pacemakers or similar medical electronic devices, maintain exposure at or below	1 kV/m (1,000 V/m)	1 gauss (1,000 mG)

Table 7. ICNIRP – Reference Levels for Time-Varying 60-Hertz Electric and Magnetic Fields

Exposure (60 Hz)	Electric Field	Magnetic Field
Occupational	8.333 kV/m (8,333 V/m)	10 G (10,000 mG)
General public	4.167 kV/m (4,167 V/m)	2 G (2,000 mG)

Reference levels are intended to be spatially distributed over the entire body of the exposed individual, but with the important proviso that the basic restrictions on localized exposure are not exceeded.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP 2010) has also developed guidelines for AC electric and magnetic fields. Table 7 presents a summary of the ICNIRP guidelines for AC electric and magnetic fields.

The Institute of Electrical and Electronics Engineers (IEEE 2002) also provides recommendations for electric and magnetic fields. These recommendations are specified for both the general public and in controlled environments.[2] Table 8 presents a summary of the IEEE guidelines for AC electric and magnetic fields.

The IEEE standard, which was drafted by its International Committee on Electromagnetic Safety (ICES), limits general public exposures to 60 Hz AC magnetic field to levels below 9,040 mG (IEEE 2002).

[2] Controlled Environment is defined by the IEEE as “An area that is accessible to those who are aware of the potential for exposure as a concomitant of employment, to individuals cognizant of exposure and potential adverse effects, or where exposure is the incidental result of passage through areas posted with warnings, or where the environment is not accessible to the general public and those individuals having access are aware of the potential for adverse effects.” (IEEE 2002)

Table 8. IEEE – AC Electric and Magnetic Field Maximum Permissible Exposure

Exposure (60 Hz)	Electric Field	Magnetic Field
General public	5 kV/m (5,000 V/m) [a,d] (from 1 Hz to 368 Hz) [c]	9.04 G (9,040 mG) [f] (from 20 Hz to 759 Hz)
Controlled environment	20 kV/m (20,000 V/m) [b,e] (from 1 Hz to 272 Hz) [c]	27.1 G (27,100 mG) [f] (from 20 Hz to 759 Hz)

a – Within power line rights-of-way, the MPE for the general public is 10 kV/m under normal load conditions.

b – Painful discharges are readily encountered at 20 kV/m and are possible at 5 – 10 kV/m without protective measures.

c – Limits below 1 Hz are not less than those specified at 1 Hz.

d – At 5 kV/m induced spark discharges will be painful to approximately 7% of adults (well-insulated individual touching ground).

e – The limit of 20,000 V/m may be exceeded in the controlled environment when a worker is not within reach of a grounded conducting object. A specific limit is not provided for this standard.

f – Anticipated harmonization with ICNIRP guideline would alter IEEE (ICES) standard to 2 G (general public) and 10 G (controlled environment).

State Engineering Standards for EMF

At least six states have implemented engineering standards for EMF within and at the edge of transmission line ROW (NIEHS 2002). In most cases the maximum fields permitted by each state are the maximum fields that existing lines produce under maximum loading conditions. Some states limit electric fields at road crossings to ensure that electric current induced into large metallic objects (such as trucks, buses, and vehicles) does not create an electric shock hazard. California developed policy that does not set specific field strength standards, but aims to lower environmental fields when the project design can be adjusted at no cost or at a low cost calculated as a percentage of total project transmission and substation costs, using 4% as a benchmark (CPUC 2006). Nevada has no regulations or engineering standards for transmission line EMFs.

Table 9. Summary of State Transmission Line Standards and Guidelines

State	Electric Field		Magnetic Field	
	On ROW	ROW Edge	On ROW	ROW Edge
Florida[1]	8 kV/m[2] 10 kV/m[3]	2 kV/m	—	150 mG[2] (max load) 200 mG[3] (max load) 250 mG[4] (max load)
Minnesota	8 kV/m	—	—	—
Montana	7 kV/m[5]	1 kV/m[6]	—	—
New Jersey	—	3 kV/m	—	—
New York	11.8 kV/m 11.0 kV/m[7] 7.0 kV/m[5]	1.6 kV/m	—	200 mG (max load)
Oregon	9 kV/m	—	—	—

1 - ROW includes certain additional areas adjoining the ROW for Florida only.

2 - For lines of 69 kV to 230 kV.

3 - For 500-kV lines.

4 - For 500-kV lines on certain existing ROW.

5 - Maximum for highway crossings.

6 - Applies in residential and subdivided areas and may be waived by the landowner.

7 - Maximum for private road crossings.

Section 3. Affected Environment

Transmission Line Configuration Types and Associated Route Alternatives

Based upon the route alternatives which have been proposed, there are a total of five different possible transmission line configurations associated with the proposed project. These possible configurations include the project 120 kV transmission line by itself, with a distribution underbuild, and located adjacent to other existing transmission lines. Table 10 presents the various route alternatives along with the various transmission line configurations which can occur within each of the routes.

Table 10. Alternative Route Descriptions and Associated Power Line Configuration Types

Alternative	Configuration Type
1 – No Action	Existing lines remain unchanged
2 – Proposed Action Stateline Alternative	Proposed 120 kV line alone Proposed 120 kV line with underbuild Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing #102 120 kV line Proposed 120 kV line with existing Distr. Line #204
3 – Mitchell Alternative	Proposed 120 kV line alone Proposed 120 kV line with underbuild Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing #102 120 kV line Proposed 120 kV line with existing Distr. Line #204
4 – Peavine Alternative	Proposed 120 kV line alone Proposed 120 kV line with underbuild Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing #102 120 kV line Proposed 120 kV line with existing Distr. Line #204
5 – Poeville Alternative	Proposed 120 kV line alone Proposed 120 kV line with underbuild Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing Alturas 345 kV line and Distribution Line #257 Proposed 120 kV line with existing #114/#106/#632 120 kV lines
6 – Stateline/Poeville Alternative	Proposed 120 kV line alone Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing #114/#106/#632 120 kV lines
7 – Peavine/Poeville Alternative	Proposed 120 kV line alone Proposed 120 kV line with existing Alturas 345 kV line Proposed 120 kV line with existing #114/#106/#632 120 kV lines

Electric and magnetic fields from the transmission lines along the proposed transmission line routes were evaluated within the right-of-way (ROW), at the edge of the ROW, and in some cases, beyond the ROW edge. EMF levels were measured and/or calculated at a height of 1 meter above ground in accordance with IEEE standard procedures for measurement of electric and magnetic fields (IEEE 1994).

EMF Measurement Locations and Results

Electric and magnetic field measurements were performed at six different site locations to characterize field levels from existing electrical facilities. Table 11 presents a summary of the locations where electric and magnetic field measurements were performed, along with the alternative route that would be associated with this transmission line configuration. Electric and magnetic field measurements were performed on Thursday, November 8, 2012 at six locations, with additional measurements performed on Thursday, November 29, 2012 at North Virginia Street near the existing Alturas 345 kV line.

Table 11. Field Measurement Locations and Associated Alternative Routes

Field Measurement Location	Alternative Route
Existing Alturas 345 kV Line – Near Long Valley Road	2, 3, 4, 5, 6, 7
Existing #102 120 kV Line – Henness Pass Road	2, 3, 4
Existing Distribution Line #204 – Henness Pass Road	2, 3, 4
Existing Alturas 345 kV Line with Distribution Line #257 – At North Virginia Street	5
Existing #114/#106/#632 120 kV Lines – Verdi Library	5, 6, 7
Existing #114/#106/#632 120 kV Lines – Verdi Elementary School	5, 6, 7
Existing #114/#106/#632 120 kV Lines – Residential Area	5, 6, 7

Site Measurement Equipment

EMDEX II magnetic field digital exposure meters were used to measure power-frequency (60 Hertz) AC magnetic field levels for this study. The EMDEX II is a computer-controlled, three-axis, AC exposure meter. Each of the three-axis sensors measures the magnetic field and the on-board computer calculates a resultant field value (the resultant is comparable to a maximum field value and is calculated as the square root of the sum of the squares for all three orthogonal axes (B_r=SQRT[$B_x^2 + B_y^2 + B_z^2$]). The data are stored in the computer's memory and downloaded to a personal computer for analysis following the measurement session. In addition, an LCD digital display on the EMDEX II allows the user to see the magnetic field data as they are stored in the computer's memory. The EMDEX II meter has a measurement range of 0.1 milligauss (mG) up to 3,000 mG (3 gauss) in the frequency range of 40 to 800 Hertz. The EMDEX II recorded the magnetic field at a sample rate of once every 1.5 seconds. The accuracy of the EMDEX II meters is $\pm$ 2%.

An EMDEX II meter was also used in conjunction with an E-PROBE field sensor to measure power-frequency (60 Hertz) AC electric field levels during the profile measurements. The E-PROBE is a parallel-plate electric field sensor attached to an insulated fiberglass handle. The EMDEX II meter is placed between the two sensing plates of the E-PROBE and is connected to them via an external cable to record electric field data. The E-PROBE has a range of 1 V/m to 200 kV/m, with a resolution of 1 V/m and typical accuracy of ± 2%.

All EMDEX meters were calibrated using a 91-centimeter (cm) diameter Helmholtz coil in the Enertech research laboratory prior to the field measurements, in accordance with IEEE/ANSI Standards (IEEE 1994). Vertical magnetic fields are generated with magnitudes ranging from 0.5 mG to 1000 mG and with absolute accuracy of +2 percent above 10 mG and +15 percent at 1 mG. Calibration for the EMDEX II meter included calibration of the electric field input for use with an E-Probe electric field sensor. Figure 3 presents a photograph of an EMDEX II meter, while Figure 4 presents a photograph of the EMDEX II and the E-Probe electric field sensor.

Measurements were conducted at 1 meter (3.28 feet) above ground level in accordance with ANSI/IEEE Standards (IEEE 1994). For electric fields, the E-Probe sensor was located at the end of an insulated fiberglass handle, held away from the measurement observer (whose presence can perturb the electric field) while conducting the readings. In addition, electric field readings were taken away from other nearby objects which can perturb the electric field reading. However, in some cases, certain objects (such as tall trees) could not be avoided at all locations and shielded/perturbed electric field measurement values are noted whenever this situation occurred. Magnetic field readings were taken away from large metallic objects (such as motor vehicles) which can perturb the magnetic field reading.

Figure 3
EMDEX II Recording Magnetic Field Meter

Figure 4
EMDEX II Recording Meter and E-Probe Electric Field Sensor

Existing Alturas 345 kV Line – Near Long Valley Road

The existing Alturas 345 kV transmission line exits the southern portion of the Bordertown Substation. The proposed project would also exit the southern portion of the Bordertown Substation and parallel the Alturas line, regardless of the various route alternatives. Therefore, this transmission line location is common to all of the possible route alternatives. Electric and magnetic field profile measurements were performed at this location to characterize existing field conditions. Figure 5 presents an aerial photograph of the measurement location.

NV Energy reported that the loading on the 345 kV transmission line was about 72 A during the measurement session (November 8, 2012 from 3 PM to 4 PM). Table 12 presents the measurement results. As shown in this table, measured electric fields ranged from about 0.091 kV/m (200-feet from centerline) to 3.360 kV/m (under the outer conductor). For magnetic fields, measured levels ranged from about 0.5 mG (200-feet from centerline) to 10.2 mG (near centerline).

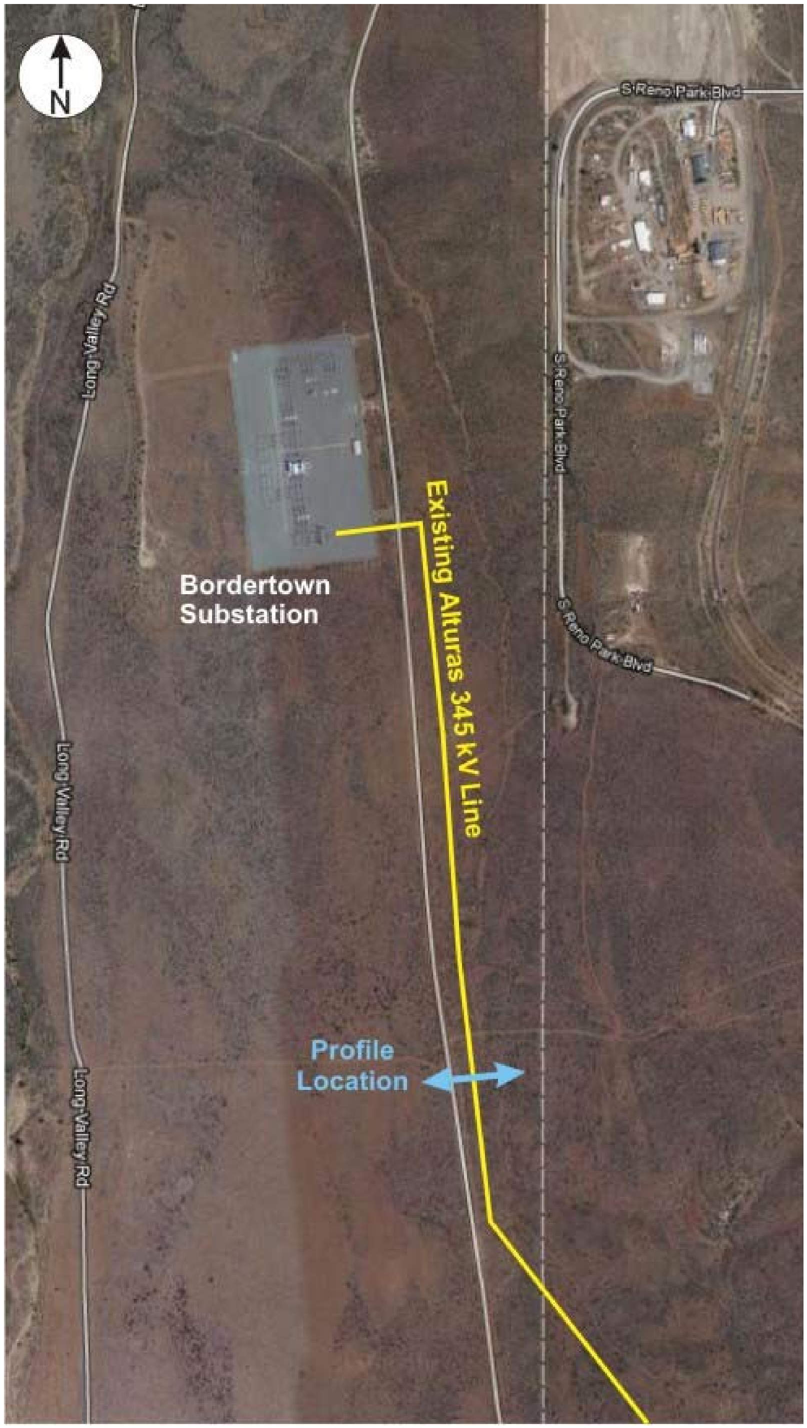
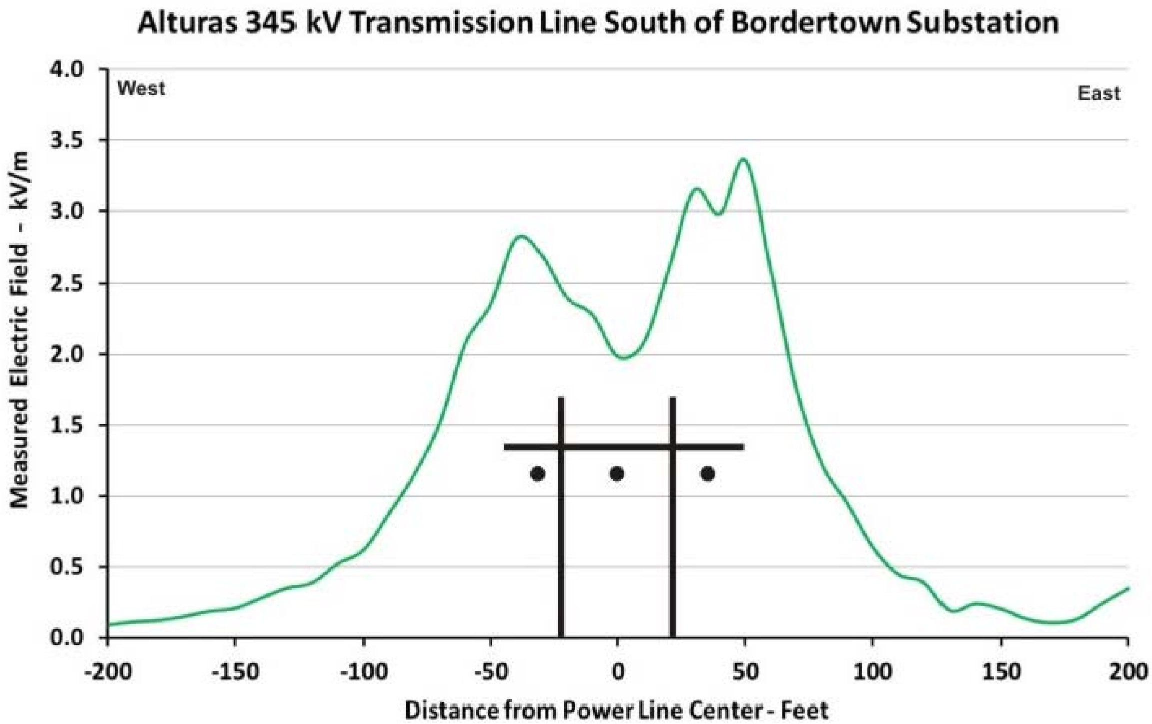


Figure 5
EMF Measurement Location for the Existing Alturas 345 kV Line South of Bordertown Substation

Table 12. Electric and Magnetic Field Measurements for Alturas 345 kV Line South of the Bordertown Substation

Distance from Alturas 345 kV Transmission Line (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-200	0.091	0.6
-190	0.112	0.6
-180	0.123	0.6
-170	0.150	0.7
-160	0.187	0.8
-150	0.208	1.0
-140	0.278	1.1
-130	0.348	1.3
-120	0.391	1.4
-110	0.525	1.7
-100	0.621	2.1
-90	0.878	2.4
-80	**1.157**	2.9
-70	**1.521**	3.5
-60	**2.079**	4.3
-50	**2.357**	5.3
-40	**2.818**	6.1
-30	**2.700**	7.0
-20	**2.400**	8.1
-10	**2.279**	9.1
0 – 345 kV Centerline	**1.982**	9.7
10	**2.079**	9.8
20	**2.604**	10.2
30	**3.150**	9.5
40	**2.979**	8.0
50	**3.360**	6.5
60	**2.604**	5.2
70	**1.768**	3.9
80	**1.232**	3.0
90	0.953	2.6
100	0.643	2.0
110	0.450	1.5
120	0.391	1.3
130	0.192	1.2
140	0.241	1.0
150	0.203	0.9
160	0.133	0.8
170	0.105	0.7
180	0.133	0.7
190	0.246	0.6
200 – Near Distribution Line	0.348	0.5

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.



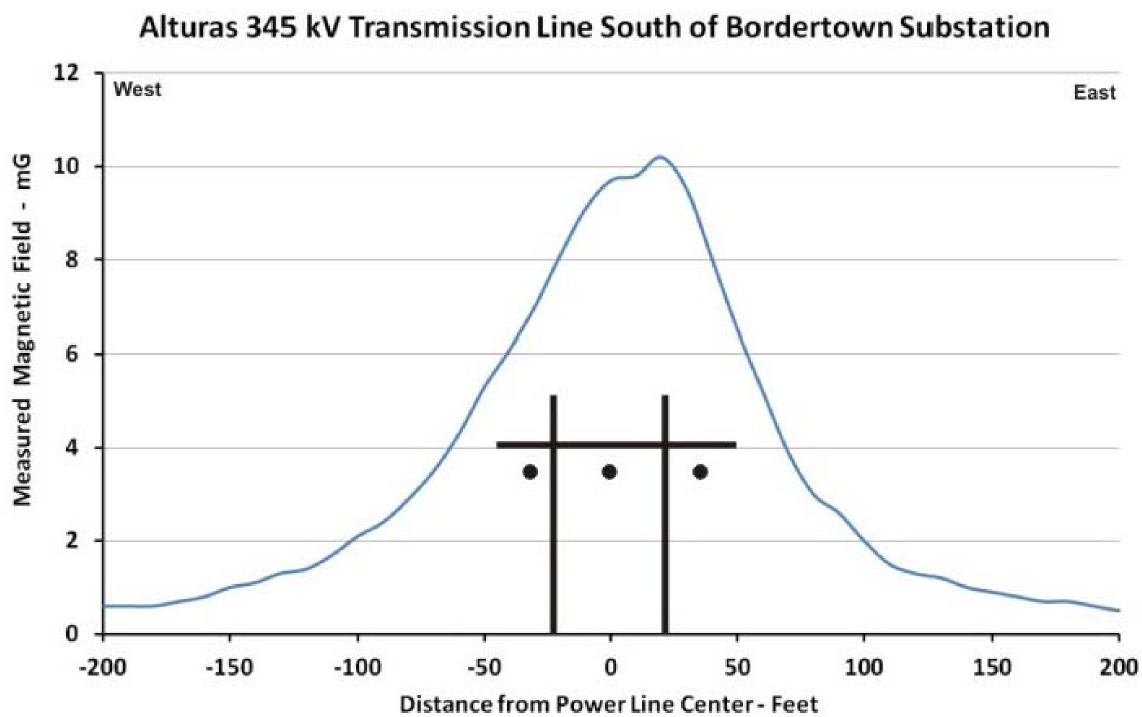


Figure 6
Graphs of the Electric and Magnetic Field Measurements for the Existing Alturas 345 kV Line South of Bordertown Substation

Existing #102 Line – Sunrise Creek Road Near Henness Pass Road

The existing Line #102 transmission line is 120 kV and exits the northwestern portion of the California Substation. The proposed project would also exit the northwestern portion of the California Substation and parallel Line #102 for the Stateline, Mitchell, and Peavine route alternatives. Electric and magnetic field profile measurements were performed on Sunrise Creek Road (near Henness Pass Road) to characterize existing field conditions. Figure 7 presents an aerial photograph of the measurement location.

NV Energy reported that the loading on the existing 120 kV transmission line was about 42 A during the measurement session (November 8, 2012 from 12 PM to 1 PM). Table 13 presents the measurement results. As shown in this table, measured electric fields ranged from about 0.000 kV/m (at 160-feet from centerline) to 0.835 kV/m (near the outside conductor). For magnetic fields, measured levels ranged from about 0.1 mG (170-feet from centerline) to 5.6 mG (near centerline).

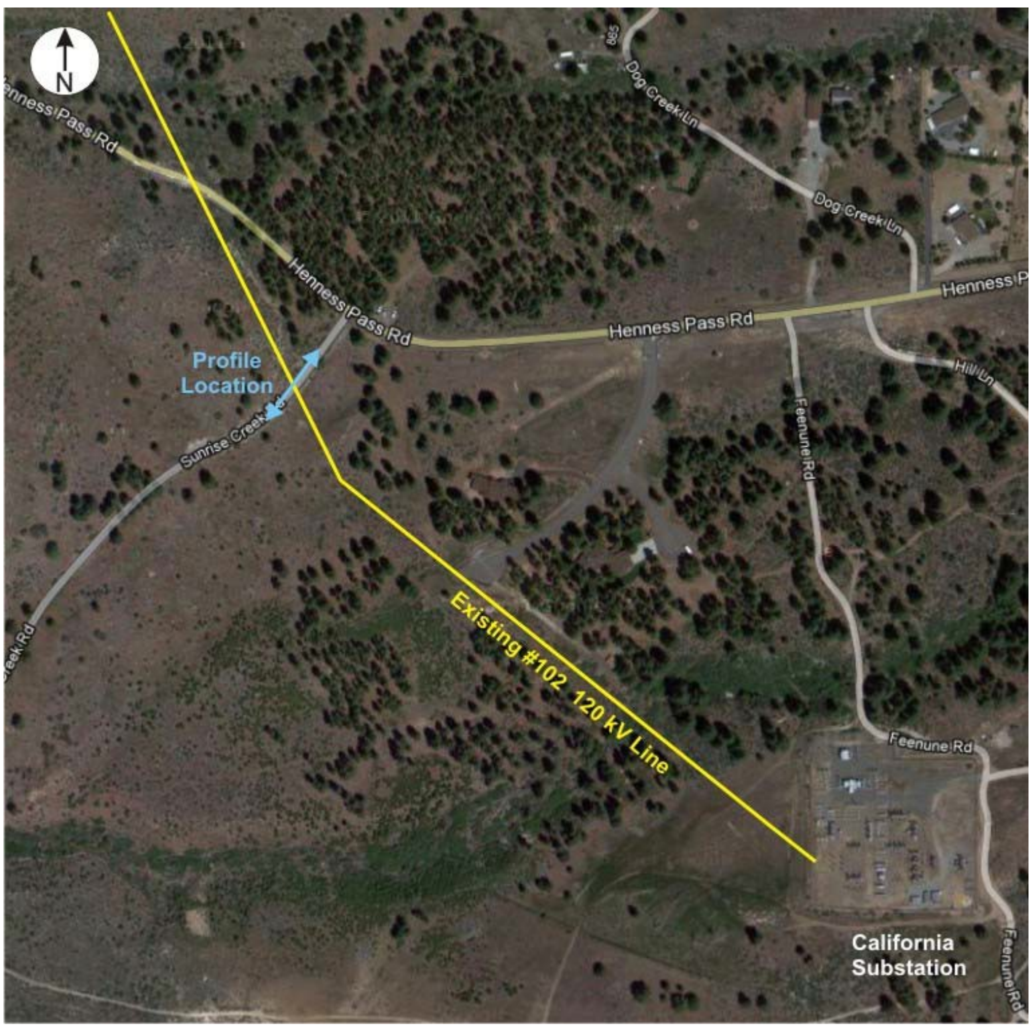
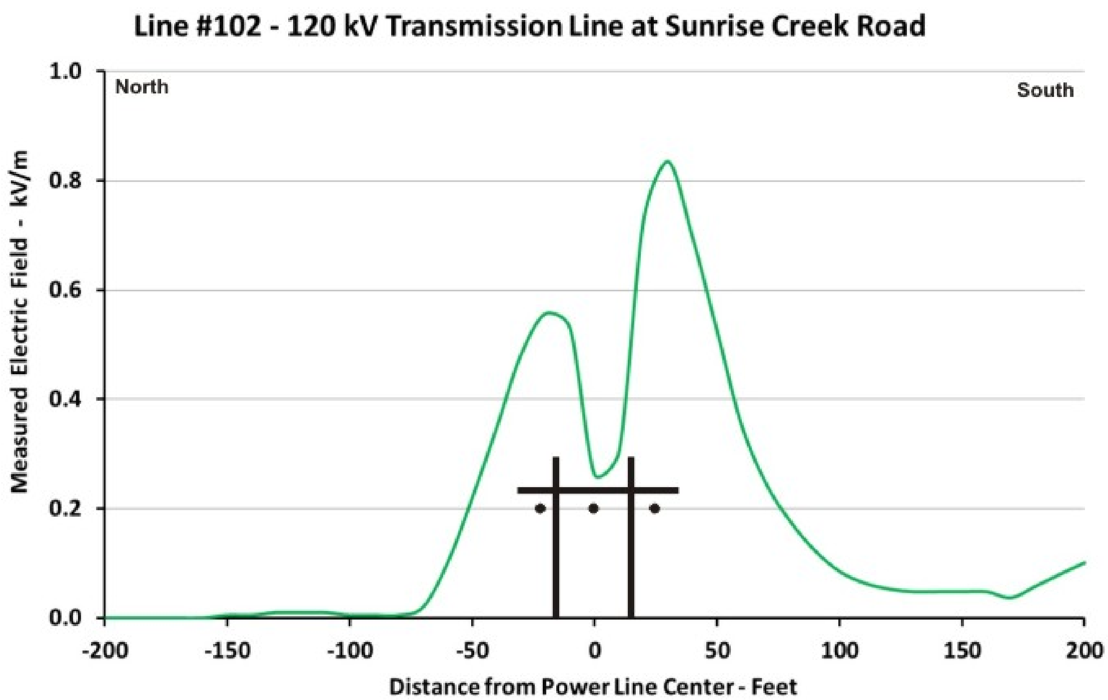


Figure 7
EMF Measurement Location for the Existing Line #102 120 kV Line near Henness Pass Road

Table 13. Electric and Magnetic Field Measurements for Line #102 at Sunrise Creek Road near Henness Pass Road

Distance from Transmission Line #102 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-200	0.000	0.1
-190	0.000	0.1
-180	0.000	0.1
-170	0.000	0.1
-160	0.000	0.2
-150	0.005	0.2
-140	0.005	0.2
-130	0.010	0.3
-120	0.010	0.3
-110	0.010	0.3
-100	0.005	0.4
-90	0.005	0.5
-80	0.005	0.7
-70	0.020	0.9
-60	0.101	1.0
-50	0.219	1.1
-40	0.348	1.5
-30	0.482	2.1
-20	0.557	2.8
-10	0.530	3.6
0 – 120 kV Centerline	0.262	4.9
10	0.305	5.6
20	0.728	5.1
30	0.835	4.4
40	0.696	3.4
50	0.525	2.6
60	0.353	1.9
70	0.246	1.5
80	0.176	1.2
90	0.123	1.0
100	0.085	0.8
110	0.064	0.7
120	0.053	0.6
130	0.048	0.5
140	0.048	0.5
150	0.048	0.5
160	0.048	0.5
170	0.037	0.4
180	0.058	0.4
190	0.080	0.4
200 –Towards Distribution Line #204	0.101	0.3



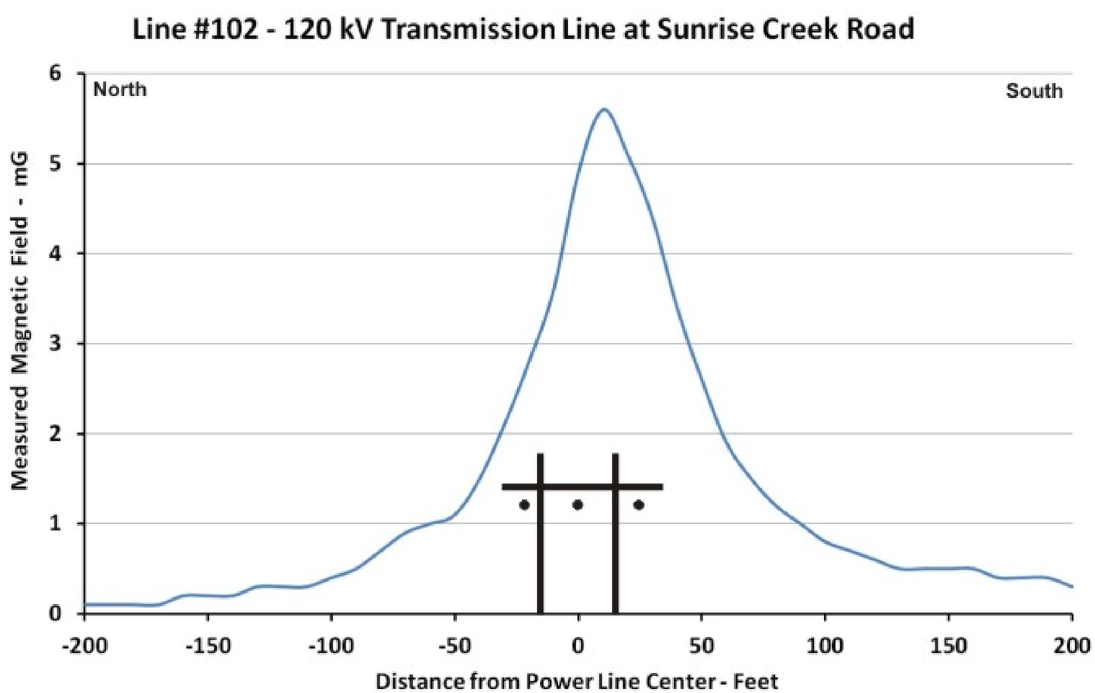


Figure 8
Graphs of the Electric and Magnetic Field Measurements for the Existing Line #102 120 kV Line at Sunrise Creek Road near Henness Pass Road

Existing Distribution Line #204 – Henness Pass Road

There is an existing distribution line (Circuit #204) which exits the northern portion of the California Substation, is routed up to Henness Pass Road, and then continues northwest along the road. Along this portion of the proposed project, this distribution line would be relocated onto the same support structures as the project 120 kV line (i.e. this would be a distribution underbuild). This project line configuration would be associated with the Stateline, Mitchell, and Peavine route alternatives. Two locations were selected for electric and magnetic field profile measurements: 1) on Henness Pass Road, and 2) on Sunrise Creek Road. Figure 9 presents an aerial photograph of these measurement locations.

Figure 9
EMF Measurement Locations for Existing Distribution Line #204 at Henness Pass Road

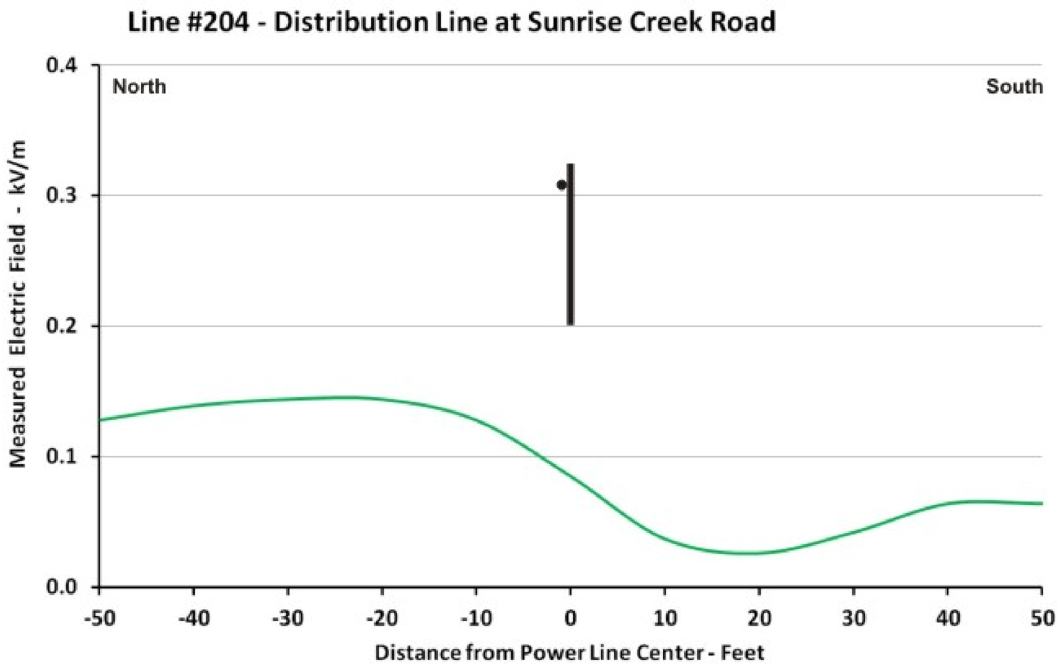
NV Energy reported that the loading on the distribution line was about 39 A during the measurement session (November 8, 2012 from 12 PM to 1 PM). Table 14 presents the measurement results at Sunrise Creek Road, while Table 15 presents the measurement results at Henness Pass Road. At 50-feet from centerline, measured electric fields ranged from about 0.058 to 0.128 kV/m (depending upon the profile location), and reached a maximum of 0.166 kV/m near centerline (Table 15). For magnetic fields, measured levels ranged from about 0.1 to 0.2 mG at 50-feet from centerline and reached a maximum of 0.4 mG towards the existing 120 kV line.

Table 14. Electric and Magnetic Field Measurements for Distribution Line #204 at Sunrise Creek Road

Distance from Distribution Line #204 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-50 – Towards 120 kV Line	0.128	0.4
-40	0.139	0.4
-30	0.144	0.4
-20	0.144	0.3
-10	0.128	0.3
0 - Centerline	0.085	0.3
10	0.037	0.2
20	0.026	0.2
30	0.042	0.1
40	0.064	0.1
50	0.064	0.1

Table 15. Electric and Magnetic Field Measurements for Distribution Line #204 at Henness Pass Road

Distance from Distribution Line #204 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-50	0.058	0.1
-40	0.085	0.2
-30	0.101	0.2
-20	0.123	0.2
-10	0.139	0.3
0 - Centerline	0.123	0.3
10	0.166	0.2
20	0.144	0.2
30	0.128	0.2
40	0.101	0.2
50	0.080	0.2



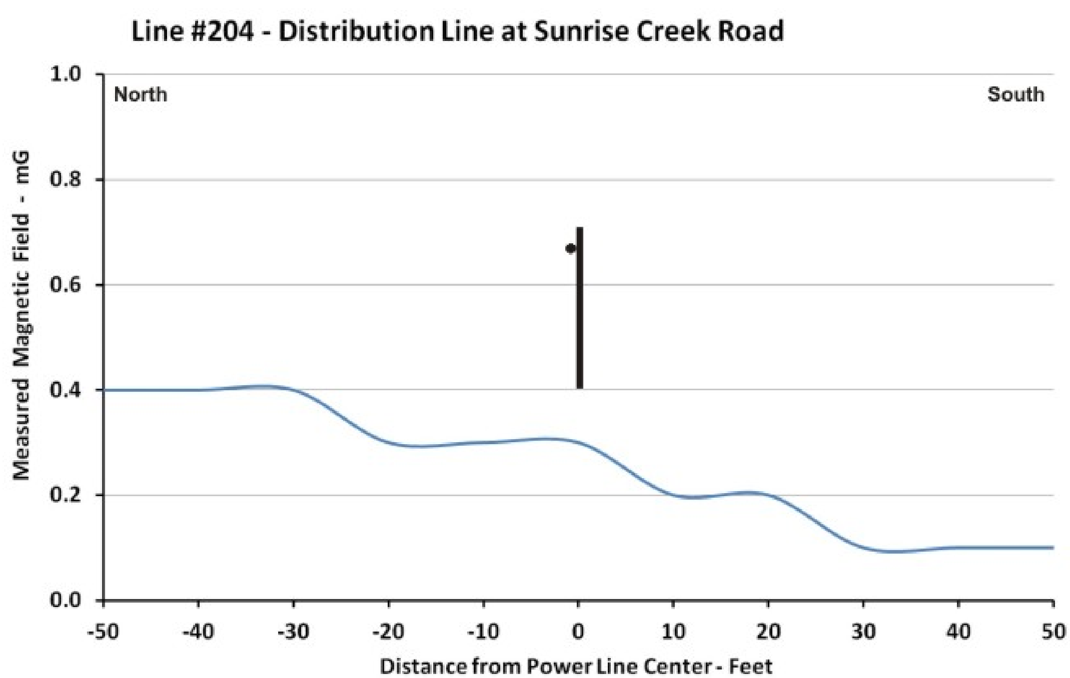
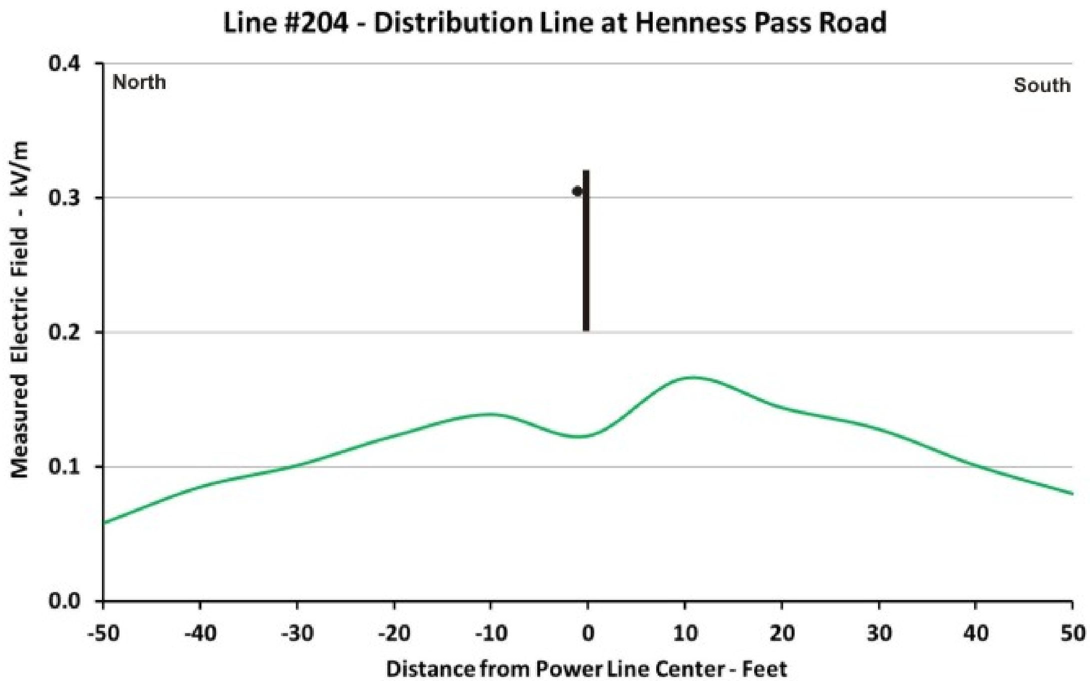


Figure 10
Graphs of the Electric and Magnetic Field Measurements for the Existing Distribution Line #204 at Sunrise Creek Road (Near Henness Pass Road)



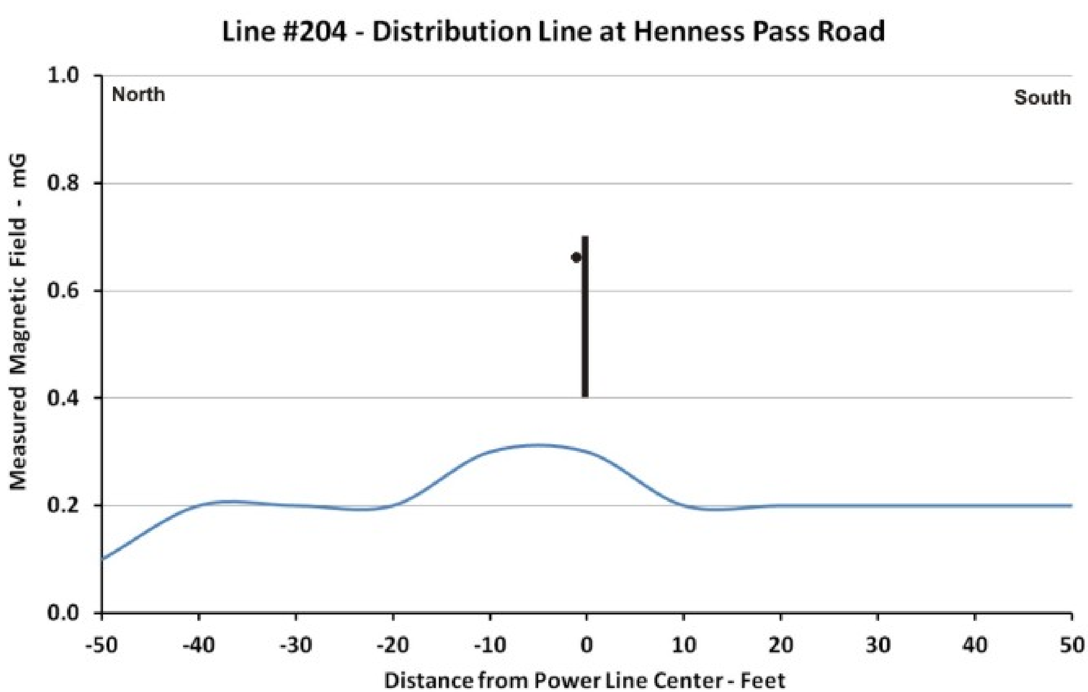


Figure 11
Graphs of the Electric and Magnetic Field Measurements for the Existing Distribution Line #204 at Henness Pass Road

Existing #114/#106/#632 Lines - Verdi

There are three existing 120 kV transmission lines routed through the city of Verdi, Lines #114, #106, and #632. NV Energy reported that Line #632 is no longer in service and therefore would not contribute to the existing electric and magnetic fields. The project line would be routed adjacent to these three existing transmission lines for the Stateline/Poeville, Poeville, and Peavine/Poeville route alternatives. Three different measurement locations were selected for electric and magnetic field profile measurements: 1) on Bridge Street adjacent to the Verdi Library and the Verdi Elementary School, 2) across the Verdi Elementary School ball field and playgrounds, and 3) in a residential area of Verdi. For the residential area, two lateral profile locations were selected for measurements, one on West Bridge Street (near Ana Mandara Creek) and the other on Lakeview Drive. Figure 12 presents aerial photographs of these measurement locations. NV Energy reported that the November 8, 2012 loading on Line #106 was about 26 A and on Line #114 was about 77 A during the measurement session (Line #632 is no longer in service).

Table 16 presents the measurement results on Bridge Street adjacent to the Verdi Library and the Verdi Elementary School. As shown in this table, measured electric fields ranged from 0.000 kV/m to 0.868 kV/m, depending upon location. For magnetic fields, measured levels ranged from about 1.2 mG to 10.9 mG. Higher field levels were measured near Line #114. An overhead distribution is routed along the entire length of Bridge Street at this measurement location, and crosses from one side of the street to the other. Two additional distribution lines are also located along the canal. Measurements were performed from 11 AM to 12 PM.

Table 17 presents the measurement results across the Verdi Elementary School ball field and playgrounds. As shown in this table, measured electric fields were below the lowest detectable level of the instrumentation (0.001 kV/m) in the ball field to 0.707 kV/m (near Line #114). For magnetic fields, measured levels ranged from about 0.1 mG (in the ball field) to 6.7 mG (near Line #114).Within the school property, measured electric fields range from 0.000 kV/m to 0.048 kV/m and magnetic fields range from 0.1 mG to 0.7 mG. Higher magnetic field levels were measured near the southern school property line (0.7 mG) than at the northern property line (0.2 mG) where the three 120 kV transmission lines are located. Measurements were performed from 9:45 AM to 11 AM.

Table 18 presents the measurement results for the residential area on West Bridge Street (near Ana Mandara Creek). As shown in this table, measured electric fields ranged from about 0.000 kV/m (110-feet from Line #114 centerline) to 0.771 kV/m (between Lines #114 & #106). For magnetic fields, measured levels ranged from about 0.4 mG (190-feet from Line #114 centerline) to 7.2 mG (near centerline of Line #114). Measurements were performed from 1:15 PM to 1:45 PM. NV Energy reported that the loading on Line #106 was about 20 A and on Line #114 was about 85 A during the residential measurement session.

Table 19 presents the measurement results for the residential area on Lakeview Drive. As shown in this table, measured electric fields ranged from about 0.010 kV/m (290-feet from centerline of Line #114) to 0.675 kV/m (near centerline of Line #114). For magnetic fields, measured levels ranged from about 0.4 mG (290-feet from centerline of Line #114) to 7.6 mG (near centerline of Line #114). Measurements were performed from 1:45 PM to 2:30 PM.

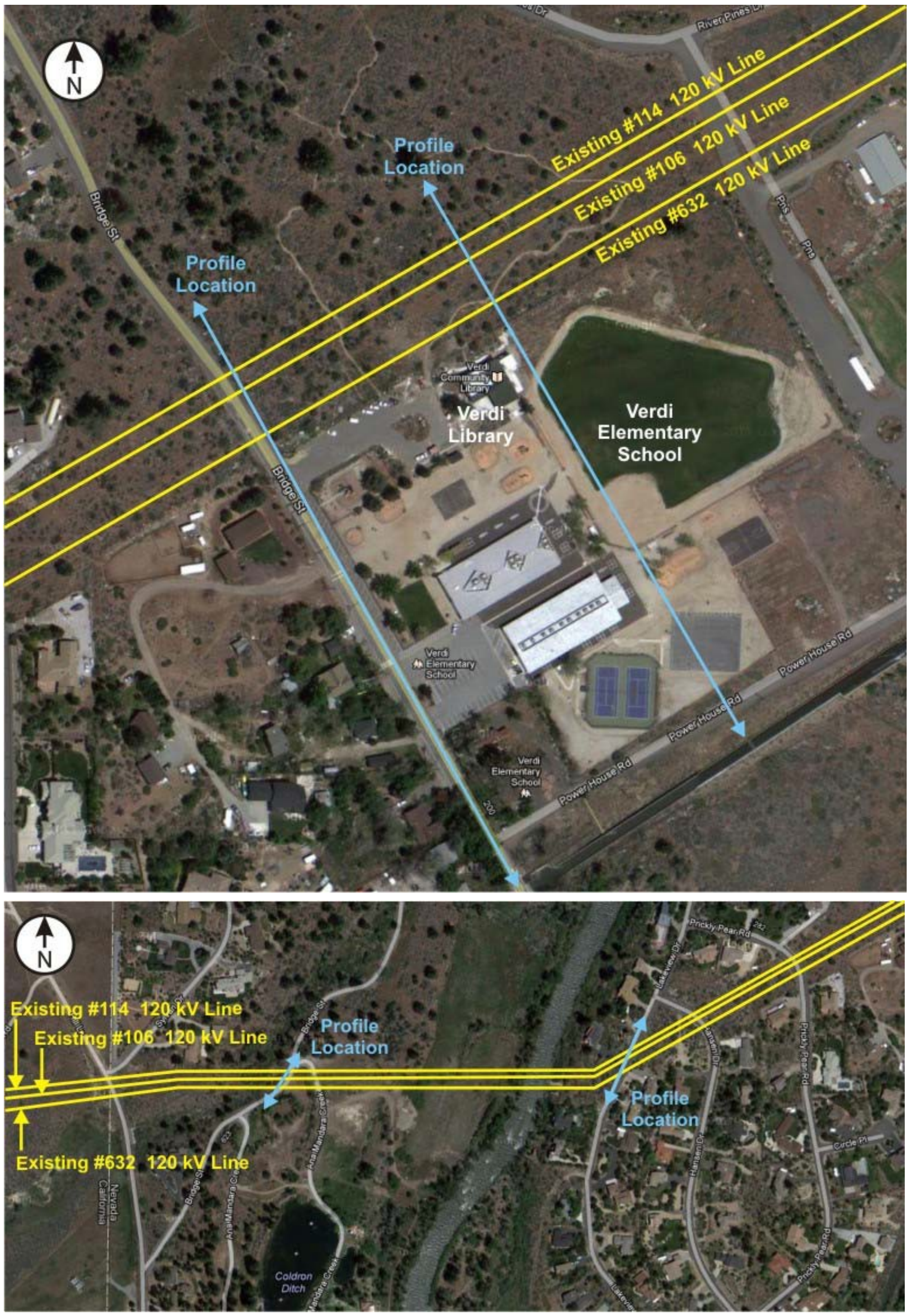


Figure 12
EMF Measurement Locations for the Three Existing 120 kV Lines in Verdi (#114/#106/#632): At the Verdi Library and Verdi Elementary School (Upper Image) and at a Verdi Residential Neighborhood (Lower Image)

Table 16. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) On Bridge Street Adjacent to Library and School

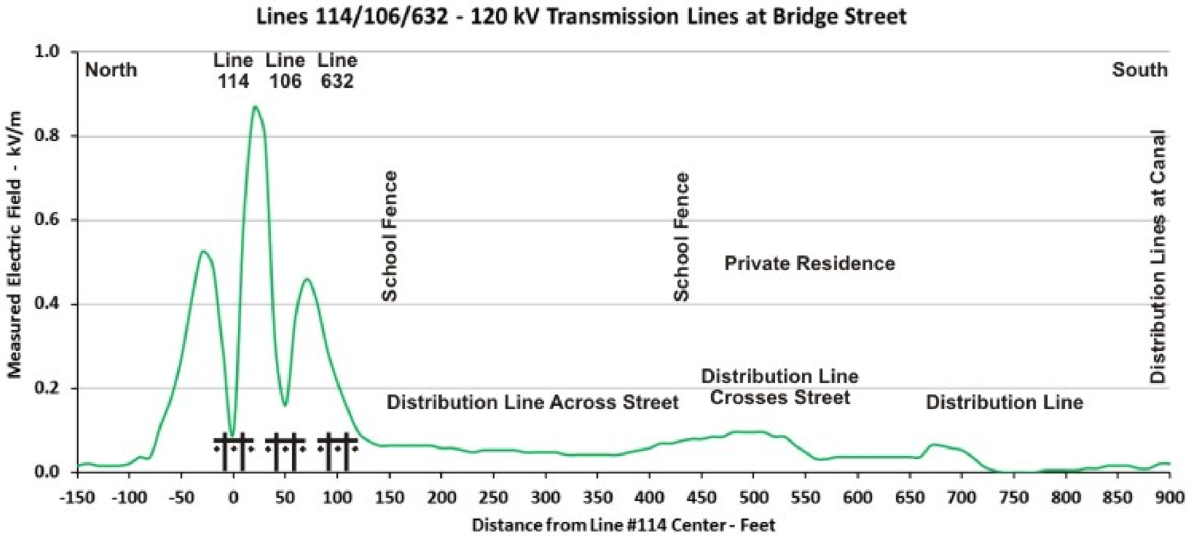
Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-150	0.016	1.6
-140	0.021	1.6
-130	0.016	1.5
-120	0.016	1.7
-110	0.016	1.5
-100	0.021	1.6
-90	0.037	1.7
-80	0.037	1.9
-70	0.112	2.3
-60	0.176	2.9
-50	0.273	3.9
-40	0.412	5.0
-30	0.525	6.7
-20	0.492	9.0
-10	0.289	10.8
0 – Line #114 Centerline	0.096	10.9
10	0.600	9.6
20	0.868	8.2
30	0.803	6.0
40 – Line #106 Centerline	0.310	4.4
50	0.160	2.6
60	0.375	2.0
70	0.460	1.8
80	0.407	1.5
90	0.294	1.4
100 – Line #632 Centerline	0.214	1.4
110	0.150	1.3
120	0.096	1.3
130	0.075	1.4
140	0.064	1.4
150 – Library Parking Lot Fence	0.064	1.2
160	0.064	1.4
170	0.064	1.3
180	0.064	1.4
190	0.064	1.4
200	0.058	1.4
210 – Edge of Playground at Library	0.058	1.5
220	0.053	1.4
230	0.048	1.4
240	0.053	1.4
250	0.053	1.4

Table 16. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) On Bridge Street Adjacent to Library and School (Continued)

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
260	0.053	1.5
270 – School Playground Fence	0.053	1.4
280	0.048	1.5
290	0.048	1.3
300	0.048	1.4
310	0.048	1.4
320	0.042	1.4
330	0.042	1.4
340	0.042	1.3
350	0.042	1.4
360	0.042	1.4
370	0.042	1.5
380	0.048	1.6
390	0.053	1.7
400	0.058	1.8
410	0.069	1.8
420	0.069	1.9
430 – Edge of School Buildings	0.075	2.0
440	0.080	2.1
450	0.080	2.3
460	0.085	2.4
470	0.085	2.4
480	0.096	2.6
490	0.096	2.7
500 – Edge of School Parking Lot	0.096	2.8
510	0.096	2.9
520	0.085	3.0
530	0.085	2.9
540	0.064	2.8
550	0.048	2.9
560	0.032	3.0
570	0.032	2.8
580	0.037	2.7
590	0.037	2.5
600	0.037	2.3
610	0.037	2.2
620	0.037	2.1
630	0.037	1.9
640 – Edge of Residence	0.037	2.0
650	0.037	1.9
660	0.037	1.8
670	0.064	1.9
680	0.064	1.8
690	0.058	1.8
700	0.053	1.8

Table 16. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) On Bridge Street Adjacent to Library and School (Continued)

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
710	0.037	1.9
720	0.016	1.9
730	0.005	1.9
740	0.000	1.9
750	0.000	1.8
760	0.000	1.9
770	0.000	1.8
780	0.005	1.7
790	0.005	1.6
800	0.005	1.6
810 – Edge of Power House Road	0.005	1.5
820	0.010	1.7
830	0.010	1.7
840 – Edge of Power House Road	0.016	1.7
850	0.016	1.9
860	0.016	1.3
870	0.010	2.3
880	0.010	2.5
890	0.021	2.3
900 – Edge of Canal	0.021	2.3



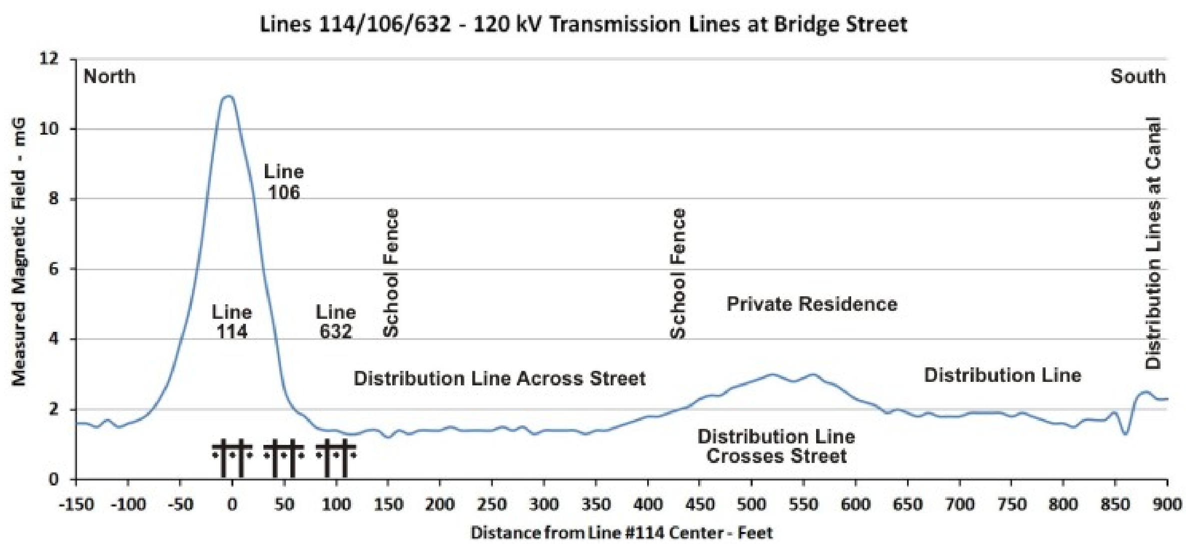


Figure 13
Graphs of the Electric and Magnetic Field Measurements for the Existing Lines #114/#106/#632 along Bridge Street near Verdi Library & Elementary School

Table 17. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) Across Verdi Elementary School Yards

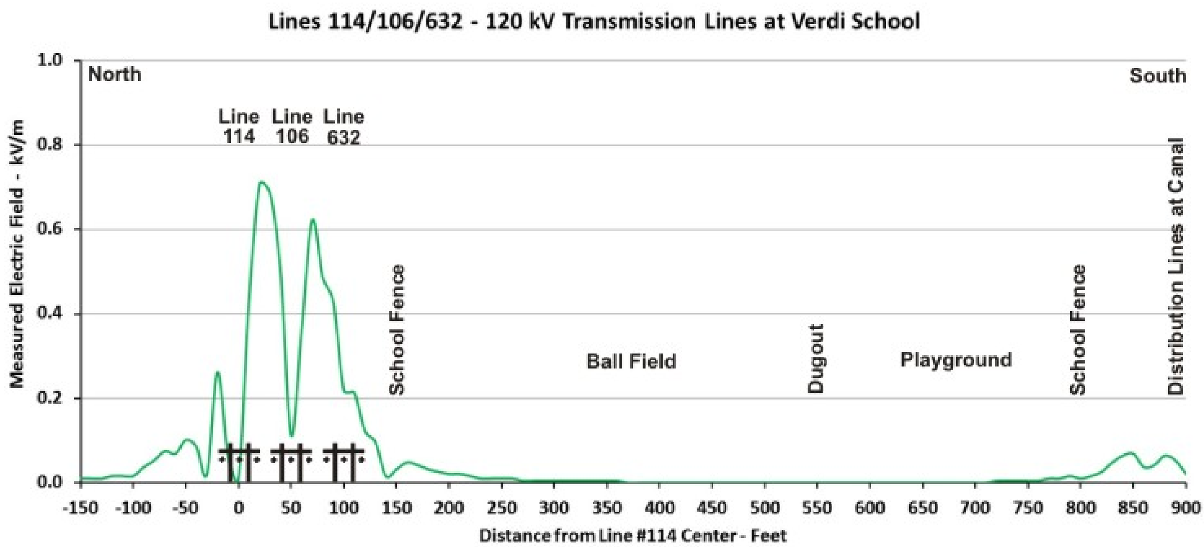
Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-150	0.010	0.4
-140	0.010	0.5
-130	0.010	0.5
-120	0.016	0.6
-110	0.016	0.7
-100	0.016	0.9
-90	0.037	1.0
-80	0.053	1.2
-70	0.075	1.5
-60	0.069	1.9
-50	0.101	2.4
-40	0.085	3.3
-30	0.021	4.4
-20	0.262	5.3
-10	0.064	6.3
0 – Line #114 Centerline	0.010	6.7
10	0.432	6.5
20	0.707	6.3
30	0.685	5.7
40	0.498	4.8
50 – Line #106 Centerline	0.112	4.1
60	0.364	2.9
70	0.621	1.4
80	0.487	0.9
90	0.428	0.5
100 – Line #632 Centerline	0.219	0.4
110	0.214	0.3
120	0.123	0.3
130	0.096	0.3
140 – School Yard Fence	0.016	0.2
150	0.032	0.5
160	0.048	0.5
170	0.042	0.4
180	0.032	0.4
190	0.026	0.4
200	0.021	0.4
210	0.021	0.4
220	0.016	0.3
230	0.010	0.2
240	0.010	0.2
250	0.010	0.2

Table 17. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) Across Verdi Elementary School Yards (Continued)

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
260	0.010	0.2
270	0.005	0.2
280	0.005	0.2
290	0.005	0.2
300	0.005	0.2
310	0.005	0.1
320	0.005	0.1
330	0.005	0.2
340	0.005	0.2
350	0.005	0.2
360	0.005	0.2
370	0.000	0.2
380	0.000	0.2
390	0.000	0.2
400	0.000	0.2
410 – Edge of School Building	0.000	0.2
420	0.000	0.2
430	0.000	0.1
440	0.000	0.1
450	0.000	0.1
460	0.000	0.1
470	0.000	0.1
480	0.000	0.1
490	0.000	0.1
500	0.000	0.2
510	0.000	0.1
520	0.000	0.2
530	0.000	0.2
540	0.000	0.2
550 – Ball Field Dugout/Bleachers	0.000	0.2
560	0.000	0.2
570	0.000	0.2
580	0.000	0.2
590	0.000	0.2
600	0.000	0.2
610	0.000	0.2
620	0.000	0.2
630	0.000	0.2
640	0.000	0.2
650	0.000	0.2
660	0.000	0.2

Table 17. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) Across Verdi Elementary School Yards (Continued)

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
670 – Basketball Court	0.000	0.3
680	0.000	0.2
690	0.000	0.2
700	0.000	0.3
710	0.000	0.3
720	0.005	0.4
730	0.005	0.4
740	0.005	0.4
750	0.005	0.4
760	0.005	0.4
770	0.010	0.5
780	0.010	0.5
790	0.016	0.6
800 – School Fence Near Residence	0.010	0.7
810	0.016	0.7
820 – Edge of Power House Road	0.026	0.9
830	0.048	0.9
840 – Edge of Power House Road	0.064	1.3
850	0.069	1.6
860	0.037	1.7
870	0.042	1.7
880	0.064	1.6
890	0.053	1.2
900 – Edge of Canal	0.021	1.0



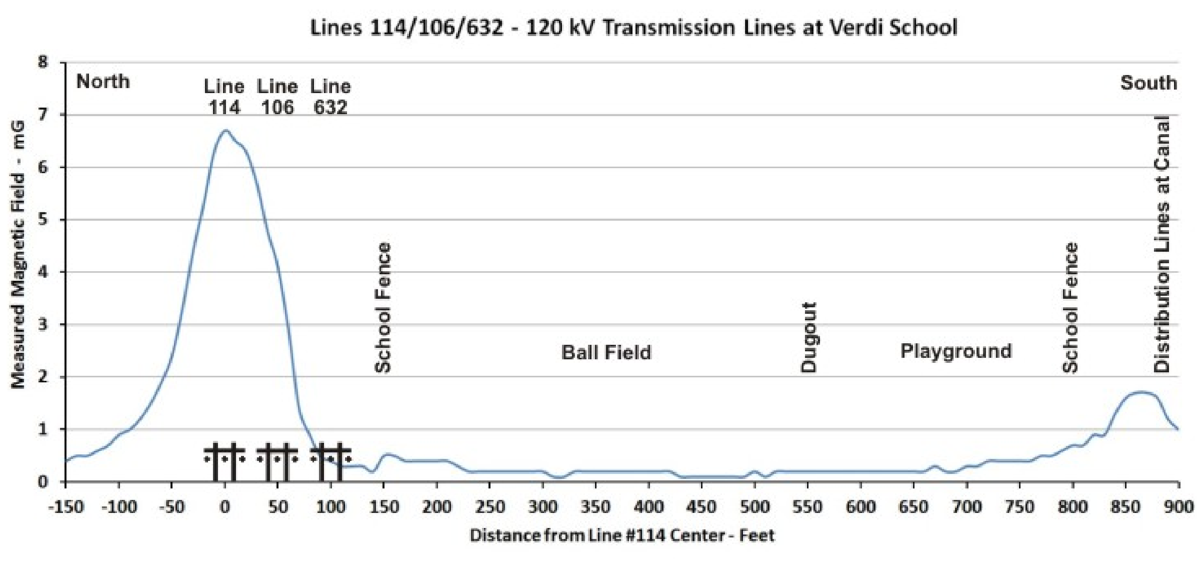
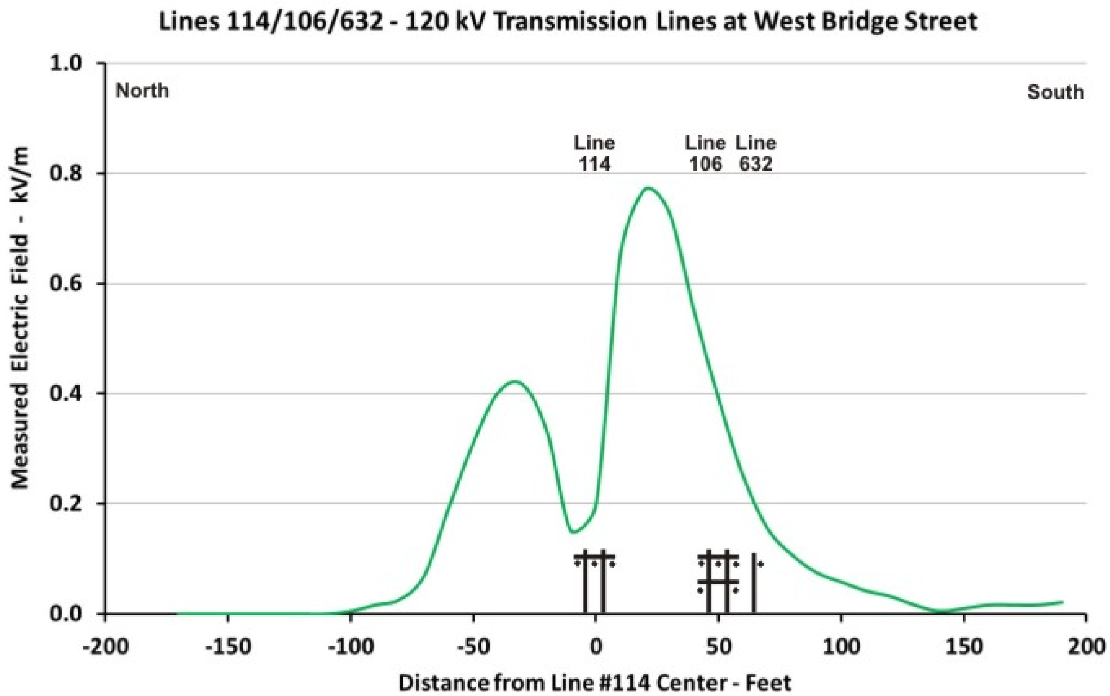


Figure 14
Graphs of the Electric and Magnetic Field Measurements for the Existing Lines #114/#106/#632 across Verdi Elementary School Ball Yard and Playground

Table 18. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) At Residential Neighborhood on West Bridge Street

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-170	0.000	0.6
-160	0.000	0.6
-150	0.000	0.8
-140	0.000	0.8
-130	0.000	0.8
-120	0.000	1.1
-110	0.000	1.2
-100	0.005	1.4
-90	0.016	1.8
-80	0.026	2.2
-70	0.069	2.5
-60	0.192	3.2
-50	0.310	4.0
-40	0.401	4.8
-30	0.417	5.8
-20	0.332	6.7
-10	0.150	7.2
0 – Line #114 Centerline	0.198	7.0
10	0.653	6.5
20	0.771	5.5
30	0.728	4.7
40 – Line #106 Centerline	0.551	3.9
50	0.391	3.2
60 – Line #632 Centerline	0.251	2.6
70	0.155	2.1
80	0.107	1.9
90	0.075	1.5
100	0.058	1.3
110	0.042	1.2
120	0.032	1.0
130	0.016	0.8
140	0.005	0.7
150	0.010	0.7
160	0.016	0.5
170	0.016	0.5
180	0.016	0.5
190	0.021	0.4



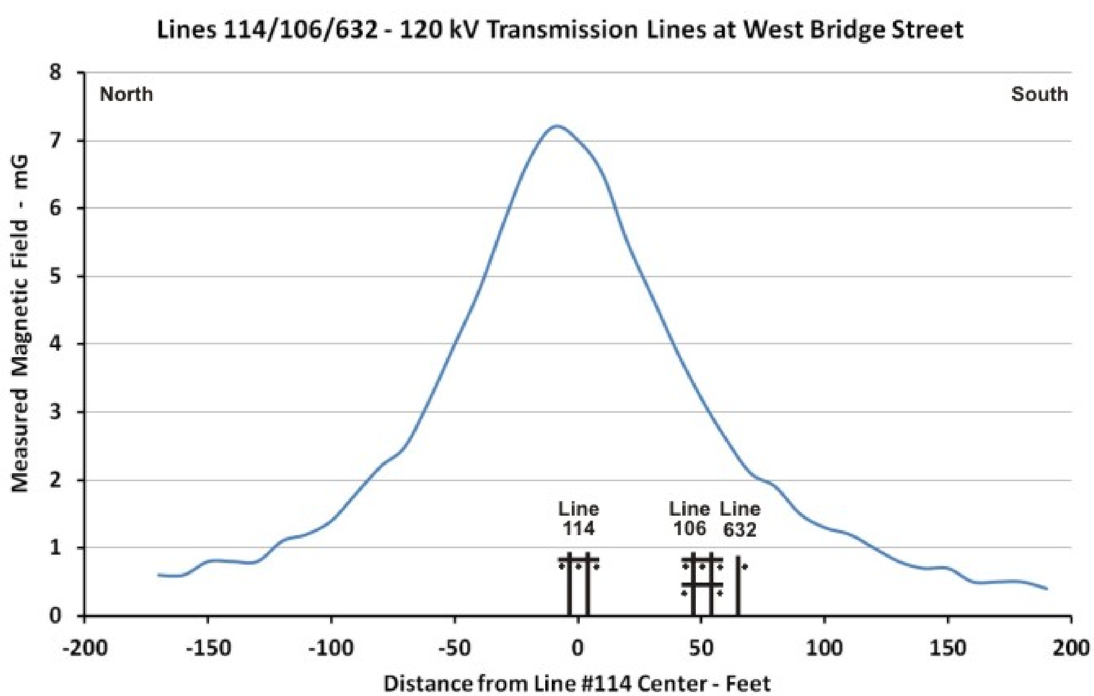


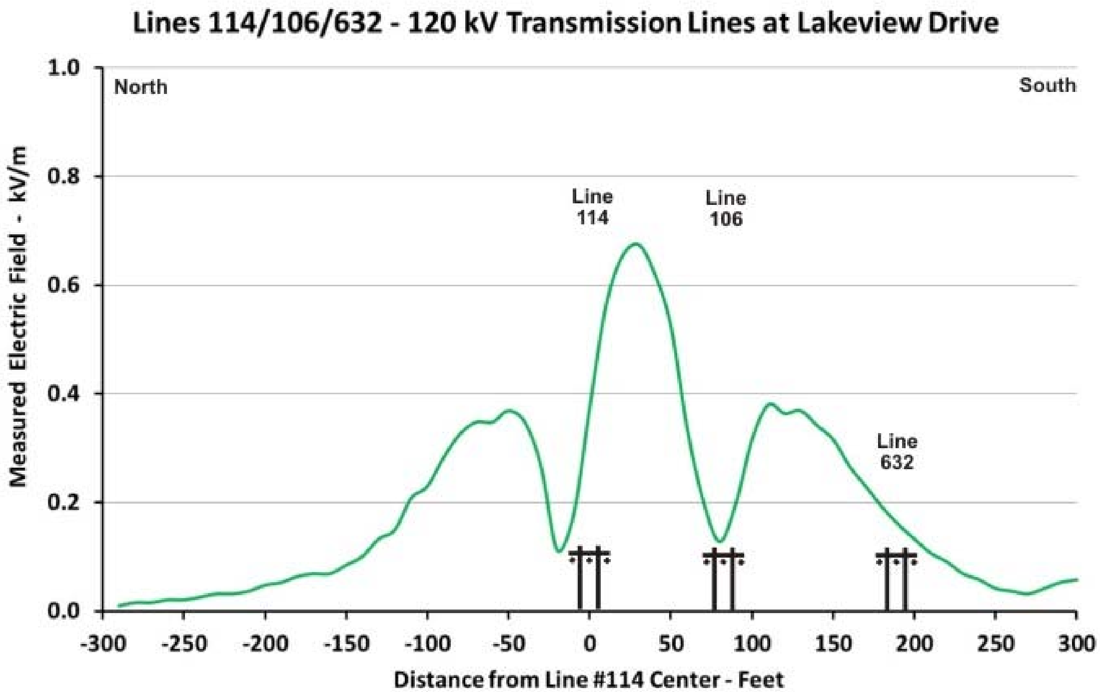
Figure 15
Graphs of the Electric and Magnetic Field Measurements for the Existing Lines #114/#106/#632 in Residential Area on West Bridge Street

Table 19. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#114/#106/#632) at Residential Neighborhood on Lakeview Drive

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
-290	0.010	1.3
-280	0.016	1.4
-270	0.016	1.4
-260	0.021	1.4
-250	0.021	1.4
-240	0.026	1.3
-230	0.032	1.3
-220	0.032	1.3
-210	0.037	2.1
-200	0.048	2.3
-190	0.053	2.4
-180	0.064	2.4
-170	0.069	3.0
-160	0.069	2.8
-150	0.085	3.0
-140	0.101	3.2
-130	0.133	3.0
-120	0.150	3.0
-110	0.208	2.8
-100	0.230	2.8
-90	0.283	3.2
-80	0.326	3.2
-70	0.348	3.6
-60	0.348	4.7
-50	0.369	5.0
-40	0.348	5.4
-30	0.267	6.0
-20	0.112	6.7
-10	0.176	7.1
0 – Line #114 Centerline	0.375	7.6
10	0.562	7.4
20	0.653	7.0
30	0.675	7.3
40	0.621	6.8
50	0.525	6.0
60	0.337	5.4
70	0.203	4.3
80 – Line #106 Centerline	0.128	3.7
90	0.198	3.0
100	0.316	2.6
110	0.380	2.4
120	0.364	1.8
130	0.369	1.4

Table 19. Electric and Magnetic Field Measurements for the Three 120 kV Lines (#106/#114/#632) at Residential Neighborhood on Lakeview Drive (Continued)

Distance from Transmission Line #114 (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
130	0.369	1.4
140	0.342	1.3
150	0.316	1.2
160	0.267	1.1
170	0.230	0.9
180	0.192	1.3
190 – Line #632 Centerline	0.160	1.4
200	0.133	1.5
210	0.107	1.4
220	0.091	1.4
230	0.069	1.3
240	0.058	1.3
250	0.042	1.3
260	0.037	1.1
270	0.032	0.9
280	0.042	0.6
290	0.053	0.4
300	0.058	0.4



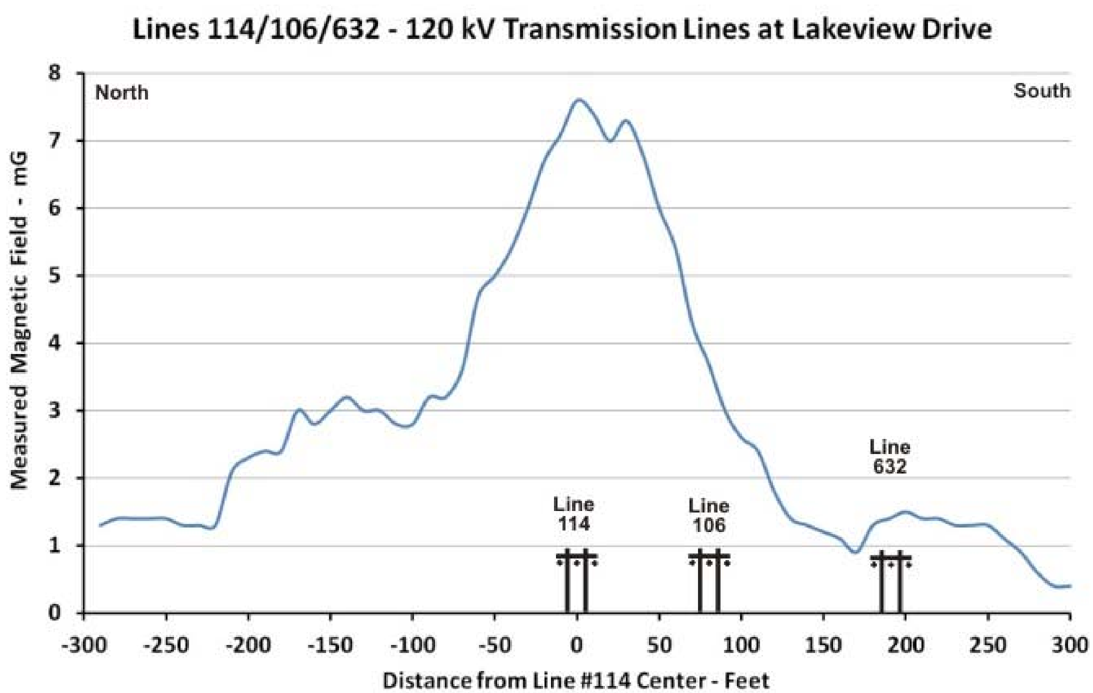


Figure 16
Graphs of the Electric and Magnetic Field Measurements for the Existing Lines #114/#106/#632 in Residential Area on Lakeview Drive

Existing Alturas 345 kV Line – At North Virginia Street

For the Poeville route alternative, the project transmission line would parallel the existing Alturas 345 kV transmission line along North Virginia Street near Reno. An overhead distribution line (#257) is also present across North Virginia Street. Electric and magnetic field profile measurements were performed at this location to characterize existing field conditions. Figure 17 presents an aerial photograph of the measurement location. Due to the presence of a roadside fence, measurements were initiated about 20-feet away from centerline of the Alturas 345 kV transmission line.

NV Energy reported that the loading on the 345 kV transmission line was about 157 A and about 127 A on distribution line #257 during the measurement session (November 29, 2012 from 1 PM to 1:30 PM). Table 20 presents the measurement results. As shown in this table, measured electric fields ranged from 0.000 kV/m to 1.007 kV/m near the 345 kV transmission line. Trees and bushes were present along the residential driveway which provided shielding of the electric field (starting at about 80-feet away from the 345 kV transmission line center and continuing throughout the remainder of the profile measurements). For magnetic fields, measured levels ranged from about 0.7 mG at the end of the residential driveway to 5.6 mG near the Alturas 345 kV transmission line. At the residence, measured magnetic fields ranged from about 1.1 mG at the back of the house to about 1.5 – 1.7 mG at the front of the house. As demonstrated in the electric and magnetic field graphs presented in Figure 18, fields from the Alturas 345 kV transmission line overshadow fields from distribution line #257.

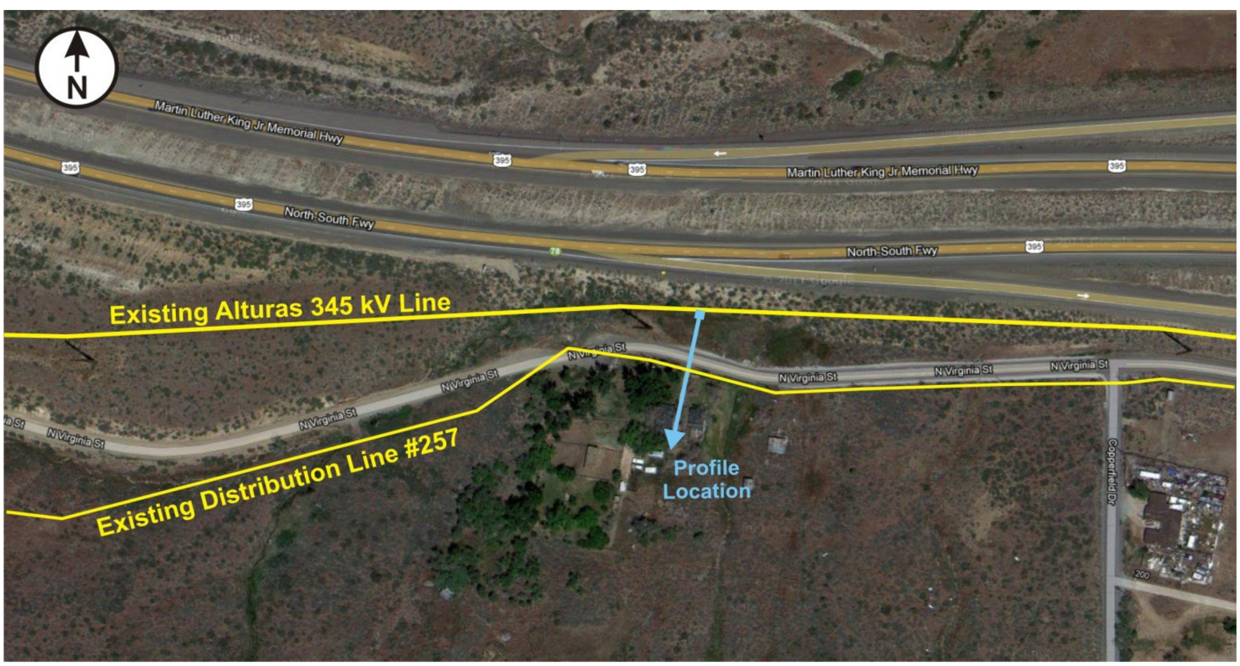
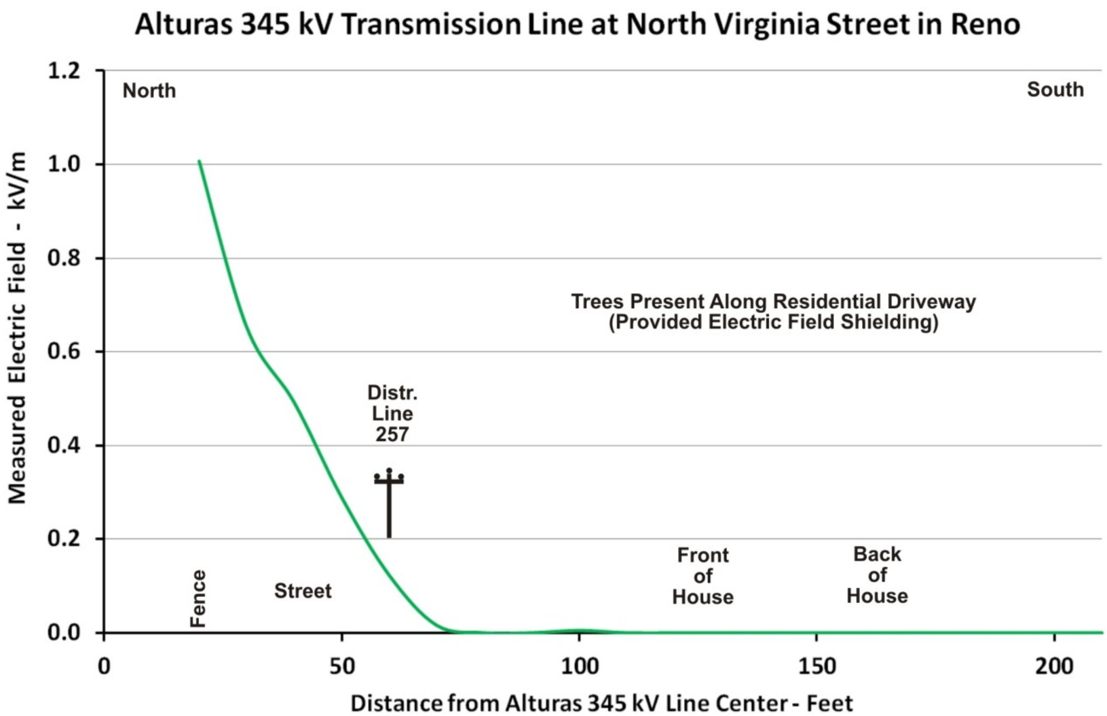


Figure 17
EMF Measurement Location for the Existing Alturas 345 kV Line at North Virginia Street

Table 20. Electric and Magnetic Field Measurements for Alturas 345 kV Line at North Virginia Street

Distance from Alturas 345 kV Transmission Line (Feet)	Electric Field (kV/m)	Magnetic Field (mG)
0 – Alturas 345 kV Centerline	N/A	N/A
10	N/A	N/A
20 – Roadside Fence	**1.007**	5.6
30	0.653	5.2
40	0.492	4.4
50	0.289	4.3
60 – Distribution Line #257	0.123	3.8
70	0.016	3.2
80 – Trees Present Along Driveway	0.000	2.5
90	0.000	2.3
100	0.005	2.0
110	0.000	1.9
120 – Front of Residence	0.000	1.7
130	0.000	1.5
140	0.000	1.3
150	0.000	1.2
160 – Back of Residence	0.000	1.1
170	0.000	1.0
180	0.000	0.9
190	0.000	0.8
200	0.000	0.7
210 – End of Driveway	0.000	0.7

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.



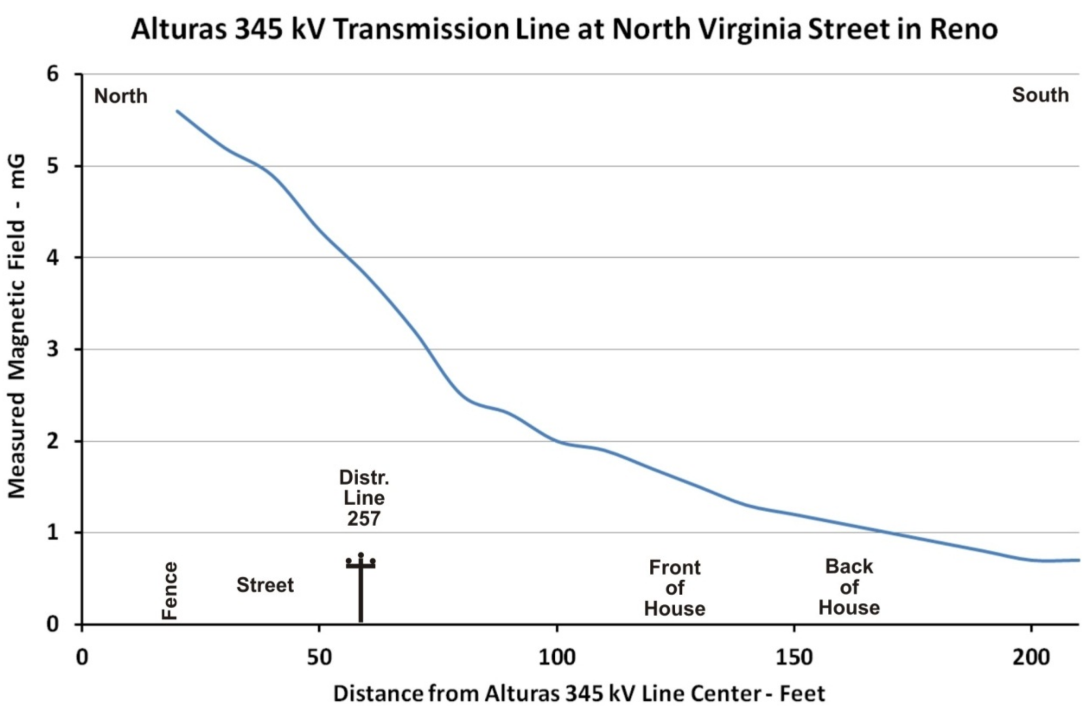


Figure 18
Graphs of the Electric and Magnetic Field Measurements for the Existing Alturas 345 kV Line and Distribution Line #257 in Residential Area on North Virginia Street

Line Loading During Field Measurements

Loading on the transmission and distribution lines was monitored by NV Energy during each of the measurement sessions. Table 21 presents a summary of the various line loading conditions during the measurement sessions, as provided by NV Energy.

Table 21. Summary of Utility Line Loading Conditions during Field Measurements as Reported by NV Energy

Line Description	Nov. 8, 2012 Measurements	Nov. 29, 2012 Measurements
Alturas 345 kV Line	72.1A	156.5A
Distribution Line #257		127.1A
Line #102 120 kV	42.4A	
Distribution Line #204	39.5A	
Line #106 120 kV	26.2A [a] / 20.2A [b]	
Line #114 120 kV	76.7A [a] / 85.0A [b]	
Line #632 120 kV	Not in Service	Not in Service

a – Average loading during morning school measurements from 9:45 AM through 12:00 PM
b – Average loading during afternoon residential measurements from 1:00 PM through 2:30 PM

EMF Computer Modeling Scenarios and Results

EMF Computer Modeling Parameters

Computer Modeling Software

Electric and magnetic fields were calculated by Enertech Consultants using standard engineering methods. A computer program originally developed by the Bonneville Power Administration was used to perform these calculations (BPA 1977). This popular engineering software utilizes standard computational algorithms, has been in use for about 35 years, and is well documented in its accuracy. This software was used to perform computer modeling of the various transmission line cases and calculate resulting electric and magnetic field levels.

Computer Modeling Configurations and Assumptions

The proposed Bordertown to California Transmission Line would be configured in either a horizontal arrangement on an H-frame structure or vertically on a single pole structure with a 25 kV distribution underbuild. The transmission line geometry information (including subconductor size, number, spacing, and type; phase spacing, circuit–to-circuit spacing, ROW widths and distance between structures, and minimum ground clearance) and loading information used for the computer calculations were provided by NV Energy. Table 22 presents a brief summary of the transmission line geometry information used for the computer modeling assessment of the proposed 120 kV transmission line. NV Energy also supplied similar information for the existing transmission lines which would parallel the proposed 120 kV line. Table 23 presents a summary of the loading data provided by NV Energy for field calculations.

Table 22. Summary of Bordertown to California Transmission Line Geometry and Configuration Assumptions for EMF Computer Modeling

Power Line Parameter	H-Frame Configuration	Single Pole Configuration	25 kV Underbuild for Single Pole
Subconductor Size	1.165”	1.126”	0.447”
Subconductor Spacing	18”	18”	0”
Number of Subconductors	2	2	1
Phase Spacing (Horizontal)	14.5’	10’	6.2’
Phasing Arrangement	A-B-C Horizontal	A-B-C Vertical	B-A-C Delta
Minimum Ground Clearance	24’	34’	25’
Overvoltage Condition	5%	5%	5%

Table 23. Summary of Utility Line Loading Conditions for EMF Calculations as Reported by NV Energy

Line Description	Light Load	Medium Load	Maximum Load
Proposed Bordertown to California 120 kV	300A	428A	585A
25 kV Distribution Underbuild (Line #257) (At North Virginia Street)	140A	200A	287A
25 kV Distribution Underbuild (Line #204) (At Henness Pass Road)	-50A	-80A	-120A
Alturas 345 kV Line	175A	258A	-60A
Line #102 120 kV	160A	240A	240A
Line #106 120 kV	280A	400A	-429A
Line #114 120 kV	90A	127A	75A

Note: Load values for existing power lines are based upon the estimated loading for the proposed project after construction and energization for each loading condition specified. Existing line loads may not reach comparable loading as the proposed C2B line (i.e. maximum loading on the proposed C2B line may not create a simultaneous maximum load condition on other nearby lines) and may alter direction of power flow (load flow) on some lines.

For the field calculations, it was assumed that all circuits running in parallel would have their minimum ground clearances at the same location. Since span lengths can vary due to structure locations and topography along various portions of the line route, structures of parallel lines may not always be aligned, resulting in non-uniform span lengths. However, assuming a uniform minimum ground clearance for all circuits produces conservative results, or higher calculated field strengths (which may or may not occur for every span along the line route).

The proposed transmission line corridor near the Verdi Elementary School and the Verdi Library contains three existing 120 kV transmission lines (Line #114, Line #106, and Line #632). NV Energy reported that Line #632 is no longer in service and therefore would not contribute to the existing electric and magnetic field. Therefore, Line #632 was not included in the computer model.

EMF Computer Modeling Results

This section presents the EMF computer modeling results for each of the transmission line case studies. Plots of the electric and magnetic field levels at 1 meter above ground level across the ROW and beyond the ROW edges are provided with descriptions of the results. Seven different transmission line configurations were modeled:

- Case 1: Proposed 120 kV Line as H-Frame Configuration
- Case 2: Proposed 120 kV Line as Single Pole Configuration with 25 kV Underbuild
- Case 3: Proposed 120 kV Line as H-Frame Configuration with Existing Alturas 345 kV H-Frame Line
- Case 4: Proposed 120 kV Line as H-Frame Configuration with Existing #102 120 kV H-Frame Line
- Case 5: Proposed 120 kV Line as Single Pole Configuration with Existing Distribution Line #204
- Case 6: Proposed 120 kV Line as H-Frame Configuration with Existing #114 & #106 120 kV H-Frame Lines
- Case 7: Proposed 120 kV Line as Single Pole Configuration with 25 kV Underbuild with Existing Alturas 345 kV Vertical Line

Case 1: Proposed 120 kV Line as H-Frame Configuration

Figure 19 presents a diagram of the proposed 120 kV transmission line with a horizontal phase configuration supported on H-frame structures. The calculated electric field at the ROW edge is 0.964 kV/m, with a maximum of 2.499 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is 21.5 mG, with a maximum of 77.3 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 30.7 mG, with a maximum of 110.3 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 42.0 mG, with a maximum of 150.7 mG within the ROW. Figure 20 and Table 24 present graphical and tabular summaries of the electric and magnetic field calculations.

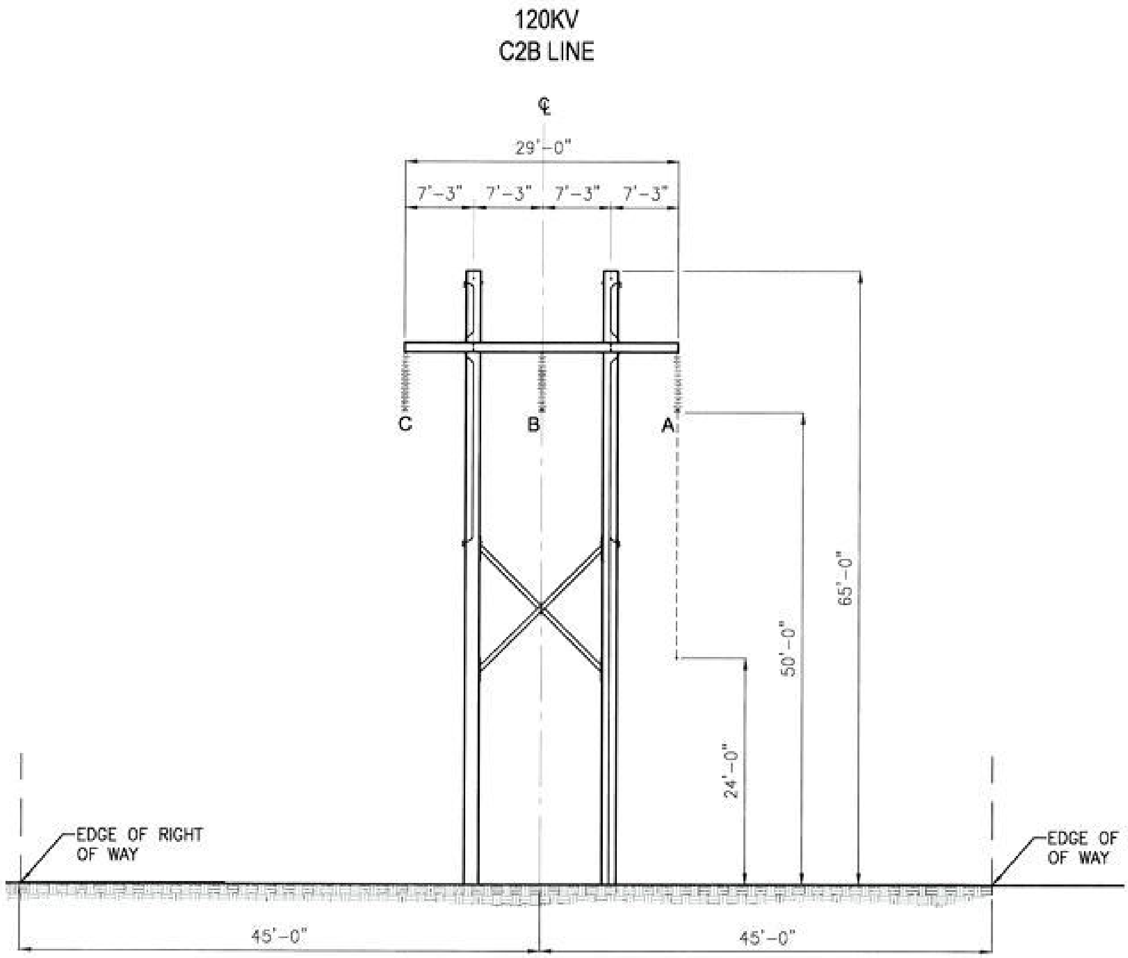
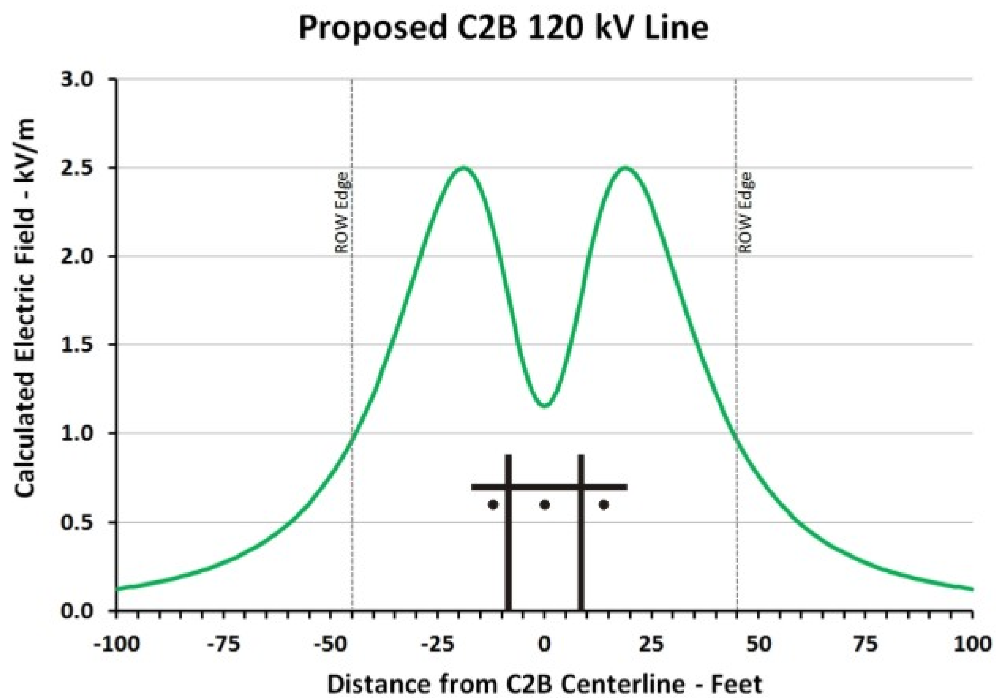


Figure 19
Case 1: Bordertown to California (C2B) Transmission Line Geometry for H-Frame Configuration (Supplied by NV Energy)



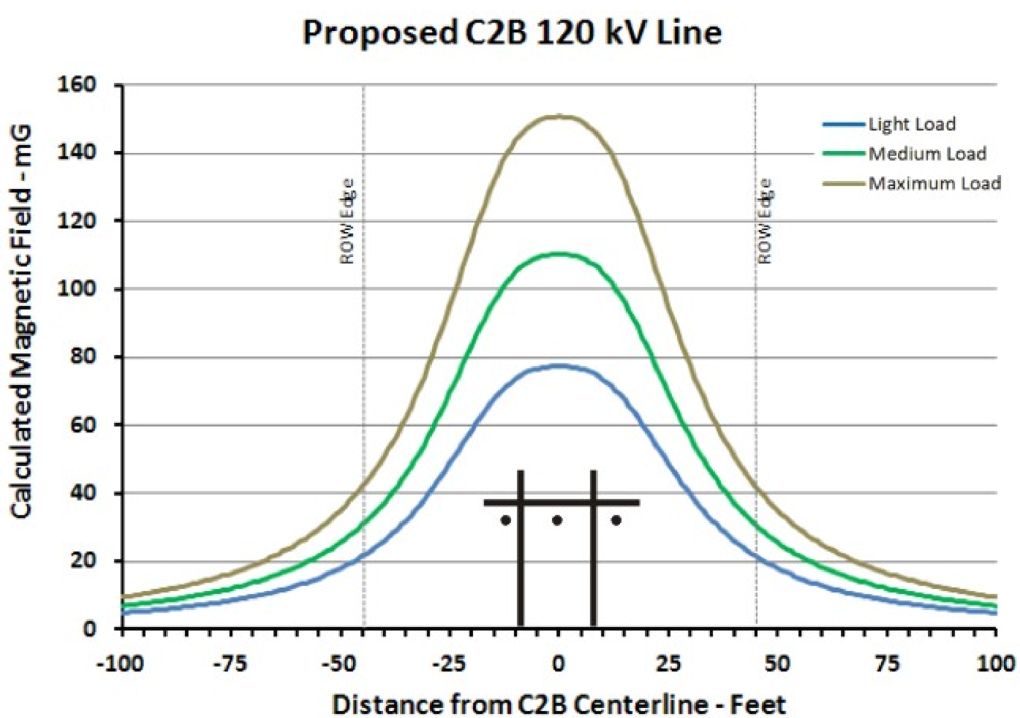


Figure 20
Case 1: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry for H-Frame Configuration

Table 24. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120kV Line as H-Frame Configuration

Distance from C2B Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-100	0.123	4.8	6.9	9.5
-90	0.165	6.0	8.5	11.6
-80	0.228	7.5	10.7	14.6
-70	0.327	9.7	13.8	18.8
-60	0.489	12.9	18.4	25.1
-50	0.762	17.9	25.6	35.0
-45 - ROW Edge	0.964	21.5	30.7	42.0
-40	**1.225**	26.2	37.3	51.0
-30	**1.926**	39.6	56.5	77.2
-20	**2.491**	58.5	83.5	114.1
-10	**1.940**	73.7	105.1	143.6
0 - C2B Centerline	**1.154**	77.3	110.3	150.7
10	**1.940**	73.7	105.1	143.6
20	**2.491**	58.5	83.5	114.1
30	**1.926**	39.6	56.5	77.2
40	**1.225**	26.2	37.3	51.0
45 - ROW Edge	0.964	21.5	30.7	42.0
50	0.762	17.9	25.6	35.0
60	0.489	12.9	18.4	25.1
70	0.327	9.7	13.8	18.8
80	0.228	7.5	10.7	14.6
90	0.165	6.0	8.5	11.6
100	0.123	4.8	6.9	9.5

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Case 2: Proposed 120 kV Line as Single Pole Configuration with 25 kV Underbuild

Figure 21 presents a diagram of the proposed 120 kV transmission line with a vertical phase configuration supported on single pole structures with a 25 kV distribution underbuild. The calculated electric field at the ROW edge is 0.519 kV/m on the two-conductor side and 0.431 kV/m on the single conductor side, with a maximum of 0.543 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is 13.2 mG on the two-conductor side and 13.9 mG on the single conductor side, with a maximum of 18.5 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 18.9 mG on the two-conductor side and 19.9 mG on the single conductor side, with a maximum of 26.3 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 26.0 mG on the two-conductor side and 27.6 mG on the single conductor side, with a maximum of 36.6 mG within the ROW. Figure 22 and Table 25 present graphical and tabular summaries of the electric and magnetic field calculations.

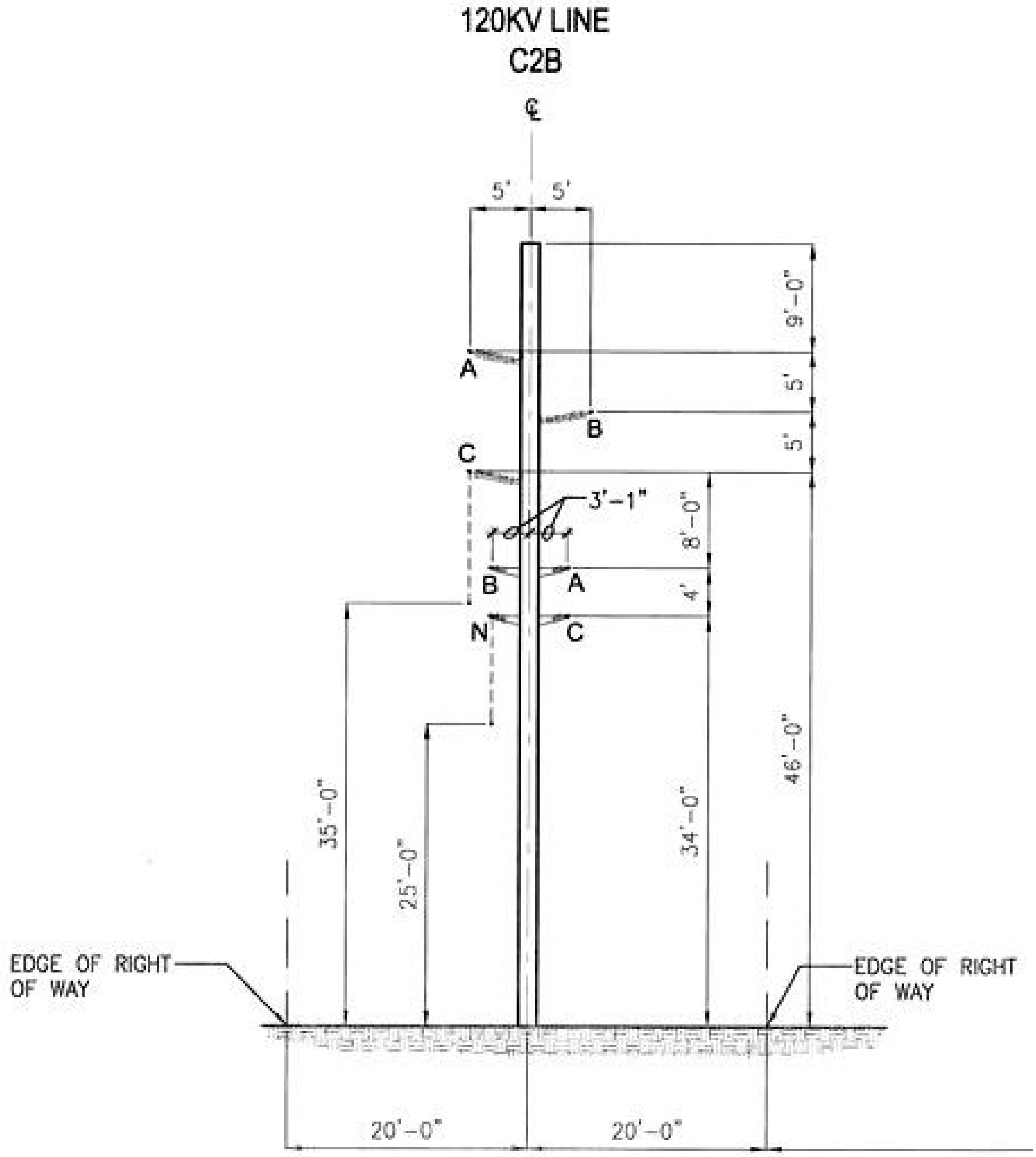
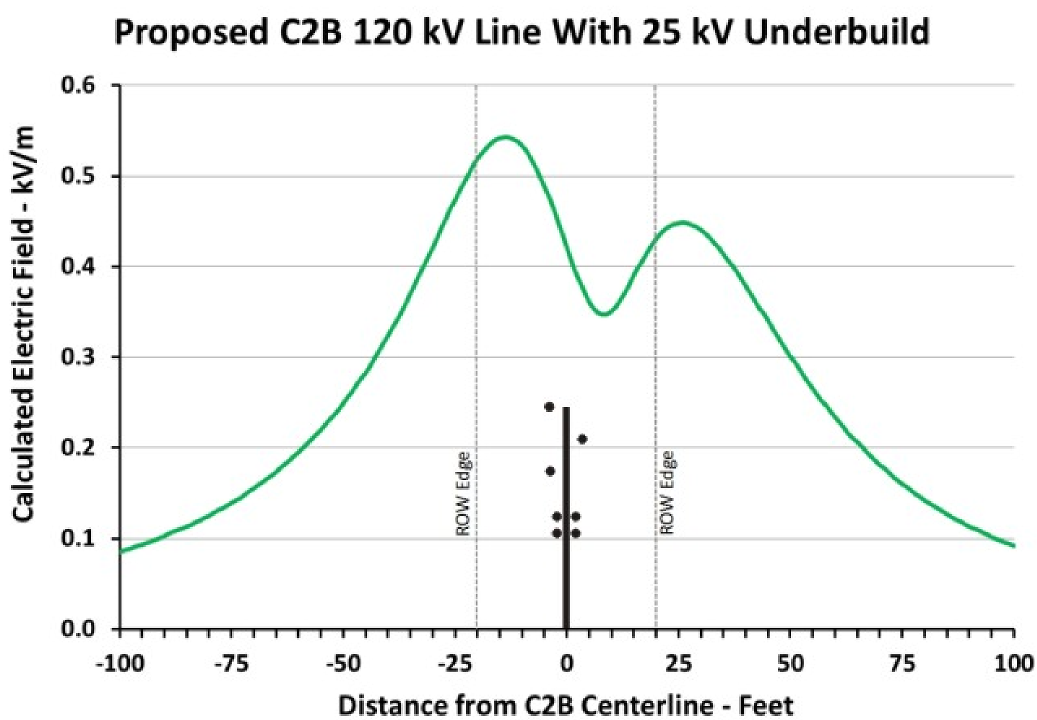


Figure 21
Case 2: Bordertown to California (C2B) Transmission Line Geometry for Single Pole Configuration (Supplied by NV Energy)



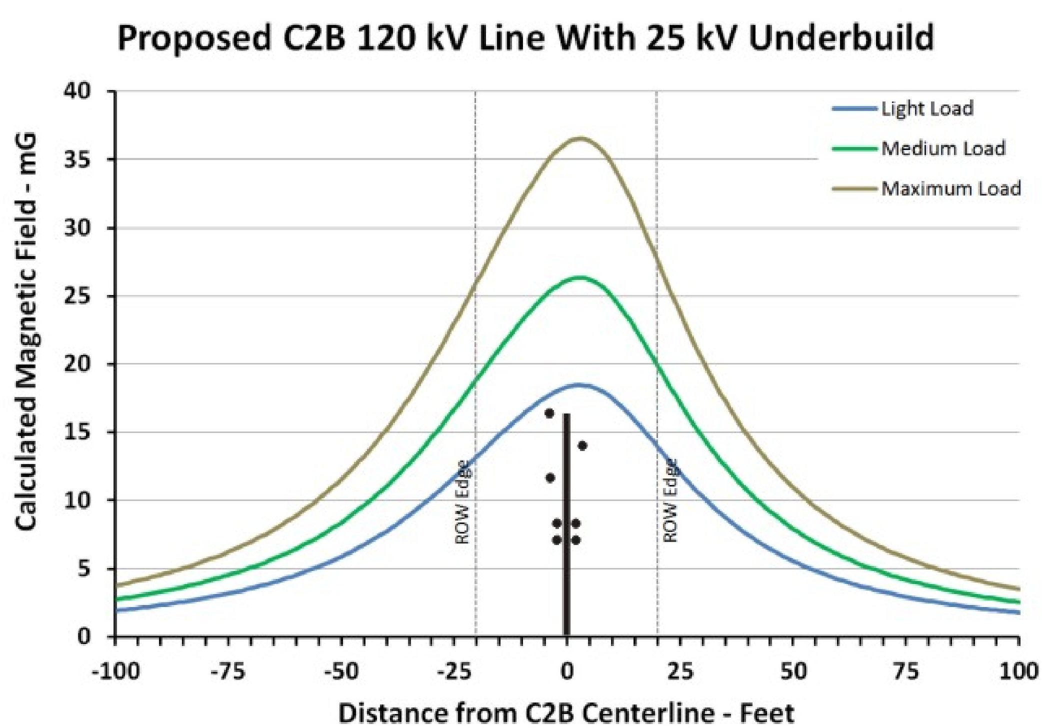


Figure 22
Case 2: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry for Single Pole Configuration

Table 25. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120kV Line with 25 kV Underbuild

Distance from C2B Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-100	0.085	1.9	2.7	3.8
-90	0.103	2.3	3.3	4.6
-80	0.125	2.8	4.1	5.6
-70	0.155	3.6	5.1	7.0
-60	0.195	4.5	6.5	8.9
-50	0.249	5.9	8.4	11.6
-40	0.323	7.8	11.1	15.2
-30	0.421	10.2	14.6	20.1
-20 - ROW Edge	0.519	13.2	18.9	26.0
-10	0.533	16.3	23.2	32.1
0 - C2B Centerline	0.422	18.3	26.1	36.3
10	0.351	17.5	25.0	34.6
20 - ROW Edge	0.431	13.9	19.9	27.6
30	0.440	10.3	14.7	20.3
40	0.379	7.5	10.7	14.8
50	0.301	5.6	7.9	11.0
60	0.234	4.2	6.0	8.3
70	0.181	3.3	4.7	6.5
80	0.142	2.6	3.8	5.2
90	0.113	2.1	3.1	4.2
100	0.092	1.8	2.5	3.5

Case 3: Proposed 120 kV Line as H-Frame Configuration with Alturas 345 kV

Figure 23 presents a diagram of the proposed 120 kV transmission line with the existing Alturas 345 kV transmission line, both in a horizontal phase configuration supported on H-frame structures as utilized south of the Bordertown Substation. For the Bordertown to California (C2B) line, the calculated electric field is 0.855 kV/m and 0.989 kV/m at the ROW edges, with a maximum of 2.517 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is about 22.1 mG for the proposed C2B line, with a maximum of 76.3 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is about 31.5 mG for the proposed C2B line, with a maximum of 108.7 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is about 41.8 mG for the proposed C2B line, with a maximum of 151.1 mG within the ROW. As shown in Table 22, the Alturas 345 kV line loading is significantly lower than the proposed C2B line; therefore calculated magnetic field levels are lower for the Alturas 345 kV line than for the proposed C2B line. Figure 24 and Table 26 present graphical and tabular summaries of the electric and magnetic field calculations. Figure 24 also presents field calculation results for the existing Alturas 345 kV transmission line by itself (with day of measurements loading) for comparison.

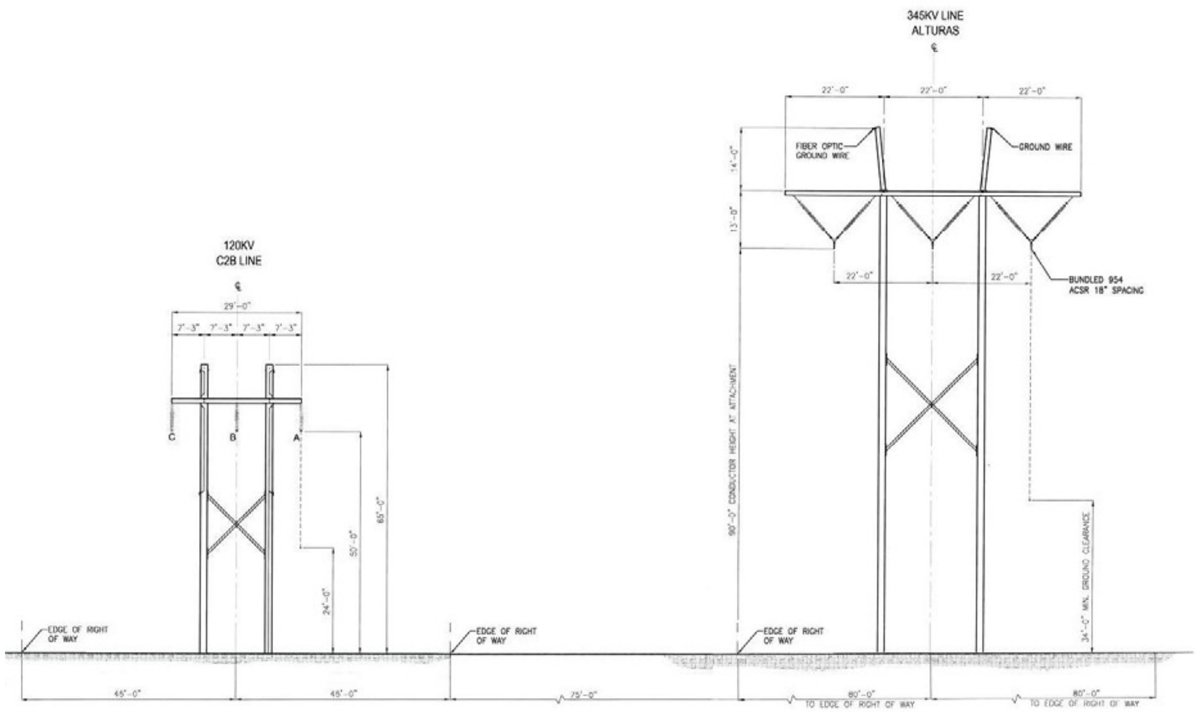


Figure 23
Case 3: Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with the Alturas 345 kV Transmission Line (H-Frame) South of Bordertown Substation (Supplied by NV Energy)

Table 26. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Alturas 345 kV South of Bordertown Substation

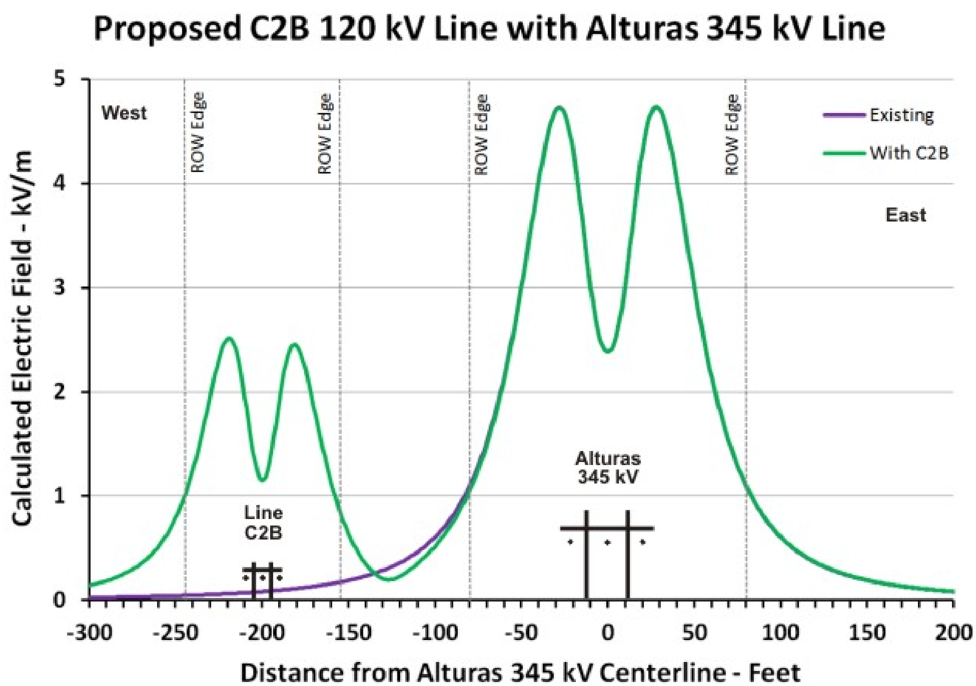
Distance from Alturas 345 kV Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-300	0.143	5.3	7.6	9.3
-290	0.186	6.5	9.2	11.4
-280	0.251	8.0	11.4	14.4
-270	0.351	10.2	14.6	18.6
-260	0.514	13.5	19.2	24.9
-250	0.787	18.5	26.4	34.8
-245 - ROW Edge for C2B	0.989	22.1	31.5	41.8
-240	**1.250**	26.7	38.1	50.8
-230	**1.948**	40.0	57.1	77.1
-220	**2.510**	58.5	83.4	114.1
-210	**1.954**	73.1	104.2	143.8
-200 – C2B Centerline	**1.148**	76.3	108.7	151.1
-190	**1.907**	72.5	103.4	144.0

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Table 26. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Alturas 345 kV South of Bordertown Substation (Continued)

Distance from Alturas 345 kV Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-180	**2.442**	57.7	82.3	114.3
-170	**1.855**	39.4	56.2	77.3
-160	**1.129**	26.4	37.7	50.9
-155 - ROW Edge for C2B	0.855	22.0	31.4	41.8
-150	0.640	18.6	26.6	34.8
-140	0.349	13.9	19.9	24.8
-130	0.207	11.0	15.8	18.4
-120	0.232	9.3	13.4	14.1
-110	0.352	8.3	11.9	11.0
-100	0.518	7.8	11.3	8.8
-90	0.739	7.8	11.4	7.2
-80 - ROW Edge for Alturas	**1.046**	8.3	12.1	6.0
-70	**1.486**	9.4	13.7	5.3
-60	**2.119**	11.2	16.4	5.3
-50	**2.990**	13.9	20.5	6.1
-40	**4.008**	17.8	26.3	7.8
-30	**4.698**	22.5	33.2	10.1
-20	**4.298**	26.6	39.3	12.0
-10	**3.007**	28.8	42.6	12.9
0 – Alturas Centerline	**2.385**	29.4	43.5	12.9
10	**3.017**	29.2	43.1	12.2
20	**4.311**	27.3	40.3	10.7
30	**4.714**	23.2	34.2	8.4
40	**4.029**	18.3	27.0	6.1
50	**3.017**	14.1	20.7	4.2
60	**2.154**	10.8	16.0	2.9
70	**1.530**	8.5	12.5	2.0
80 - ROW Edge for Alturas	**1.103**	6.8	10.0	1.4
90	0.812	5.6	8.2	1.0
100	0.611	4.7	6.9	0.7
110	0.469	4.0	5.8	0.5
120	0.367	3.4	5.0	0.4
130	0.293	3.0	4.3	0.3
140	0.237	2.6	3.8	0.3
150	0.194	2.3	3.4	0.3
160	0.161	2.1	3.0	0.2
170	0.135	1.8	2.7	0.2
180	0.115	1.7	2.4	0.3
190	0.098	1.5	2.2	0.3
200	0.085	1.4	2.0	0.3

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.



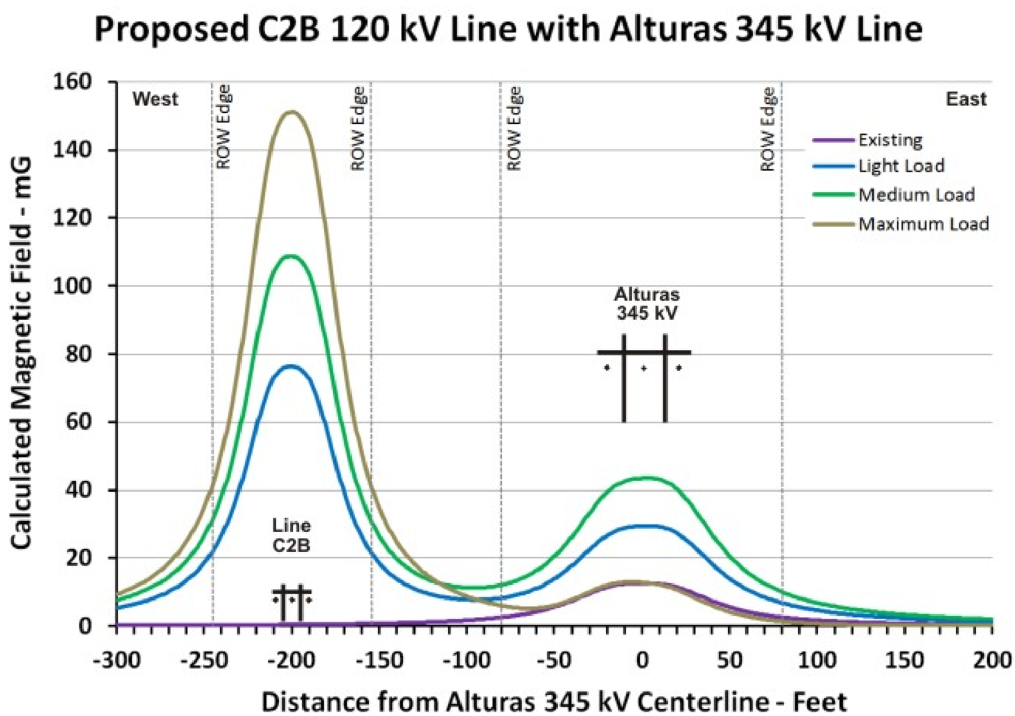


Figure 24
Case 3: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with the Alturas 345 kV Transmission Line (H-Frame) South of Bordertown Substation

Case 4: Proposed 120 kV Line as H-Frame Configuration with Line #102 120 kV

Figure 25 presents a diagram of the proposed 120 kV transmission line with the existing Line #102 120 kV transmission line, with both lines in a horizontal phase configuration supported on H-frame structures. The calculated electric field at the combined ROW edge is 0.716 kV/m close to Line #102 and 0.956 kV/m close to the proposed C2B line, with a maximum of 1.210 kV/m within the ROW near Line #102 and 2.563 kV/m near the proposed C2B line. Higher electric fields are associated with the proposed C2B line due to lower conductor ground clearances (as shown in Figure 25). For light loading, the calculated magnetic field at the ROW edge is 10.4 mG close to Line #102 and 20.8 mG close to the proposed C2B line, with a maximum of 30.8 mG within the ROW near Line #102 and 79.0 mG near the proposed C2B line. For medium loading, the calculated magnetic field at the ROW edge is 15.6 mG close to Line #102 and 29.6 mG close to the proposed C2B line, with a maximum of 45.8 mG within the ROW near Line #102 and 112.8 mG near the proposed C2B line. For maximum loading, the calculated magnetic field at the ROW edge is 15.3 mG close to Line #102 and 40.8 mG close to the proposed C2B line, with a maximum of 48.1 mG within the ROW near Line #102 and 153.2 mG near the proposed C2B line. Figure 26 and Table 27 present graphical and tabular summaries of the electric and magnetic field calculations. Figure 26 also presents the electric and magnetic field calculation results for the existing Line #102 120 kV transmission line by itself (with day of measurements loading) for comparison.

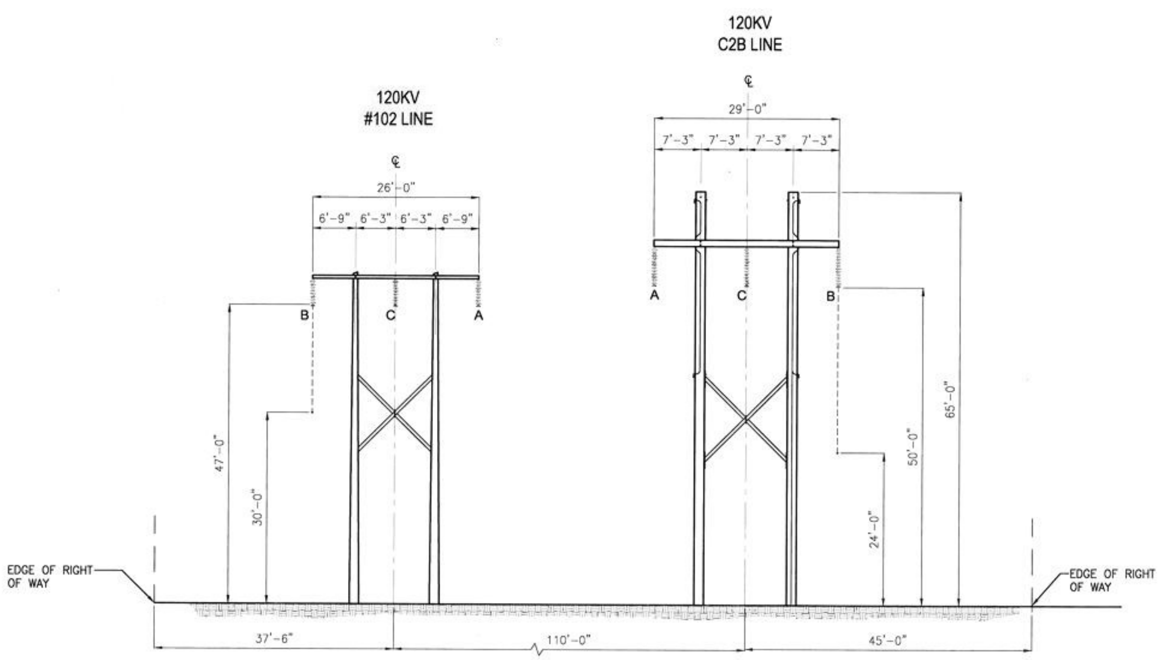
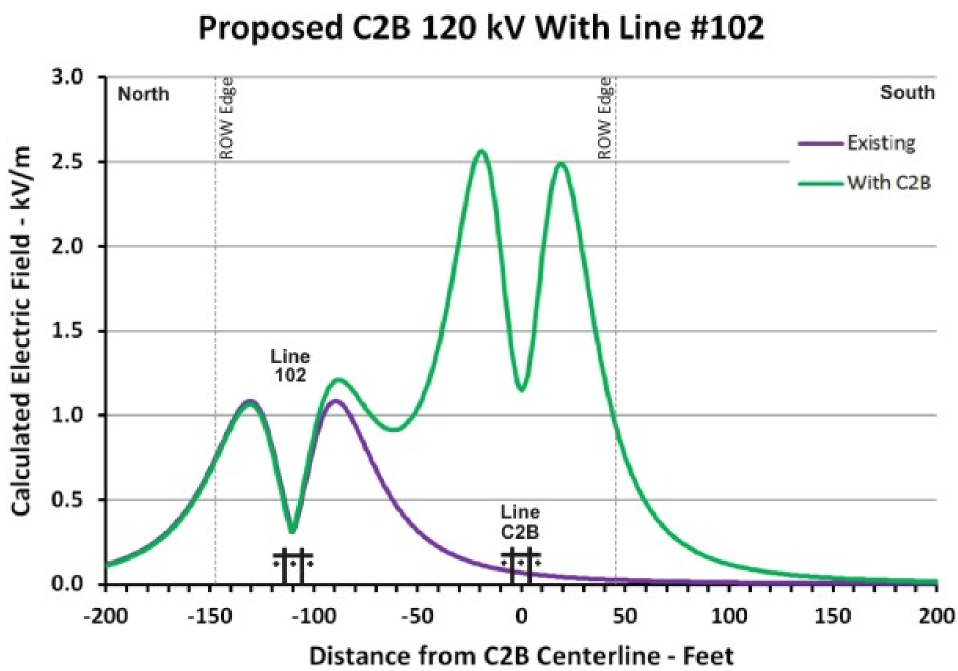


Figure 25
Case 4: Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with Line #102 (Supplied by NV Energy)



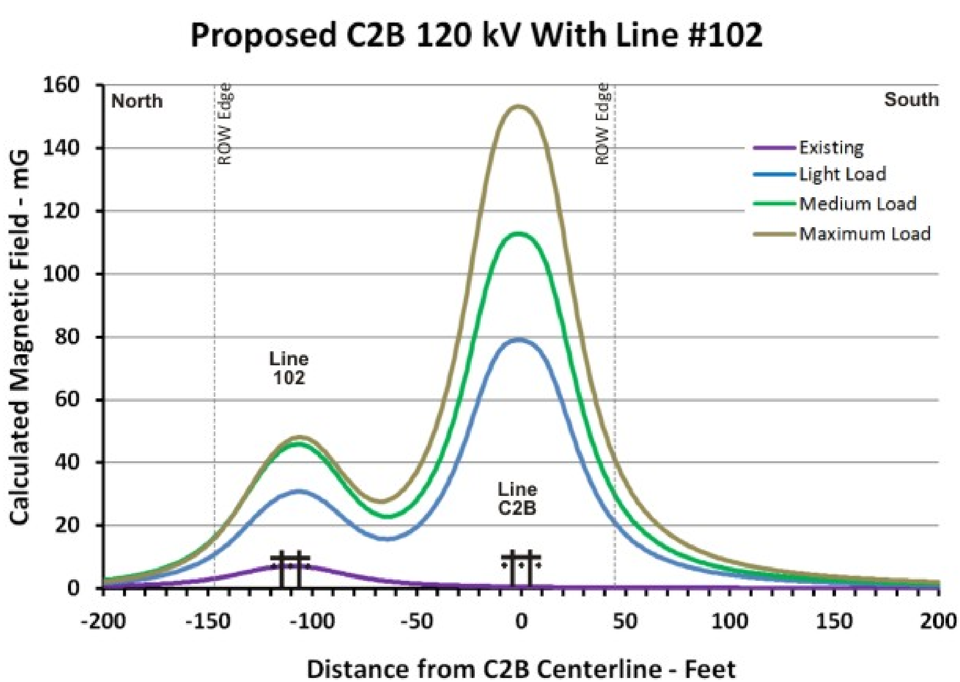


Figure 26
Case 4: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with Line #102

Table 27. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV with Line #102

Distance from C2B Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-200	0.111	1.7	2.6	2.1
-190	0.151	2.3	3.5	3.0
-180	0.213	3.1	4.8	4.2
-170	0.307	4.4	6.7	6.2
-160	0.452	6.4	9.7	9.2
-150	0.665	9.6	14.4	14.0
-148 - ROW Edge	0.716	10.4	15.6	15.3
-140	0.925	14.4	21.6	21.5
-130	**1.064**	20.9	31.3	31.7
-120	0.789	27.2	40.6	41.8
-110 – Line #102 Centerline	0.315	30.5	45.5	47.5
-100	0.883	29.8	44.4	46.9
-90	**1.202**	25.3	37.6	40.3
-80	**1.128**	19.8	29.2	32.3
-70	0.969	16.2	23.8	27.9
-60	0.916	16.0	23.2	29.3
-50	**1.043**	19.6	28.1	37.2
-40	**1.408**	27.5	39.4	52.9
-30	**2.042**	41.3	59.0	79.7
-20	**2.559**	60.7	86.7	117.3
-10	**1.972**	75.9	108.4	147.0
0 – C2B Centerline	**1.150**	78.9	112.7	153.2
10	**1.929**	74.5	106.3	144.8
20	**2.483**	58.4	83.3	113.9
30	**1.918**	39.0	55.6	76.4
40	**1.218**	25.4	36.2	49.9
45 - ROW Edge	0.956	20.8	29.6	40.8
50	0.754	17.2	24.4	33.8
60	0.482	12.2	17.3	24.0
70	0.321	9.0	12.8	17.8
80	0.223	6.9	9.7	13.6
90	0.160	5.4	7.6	10.8
100	0.119	4.3	6.1	8.7
110	0.090	3.5	5.0	7.1
120	0.070	3.0	4.2	6.0
130	0.056	2.5	3.5	5.0
140	0.045	2.1	3.0	4.3
150	0.037	1.8	2.6	3.7
160	0.031	1.6	2.3	3.3
170	0.026	1.4	2.0	2.9
180	0.022	1.2	1.8	2.5
190	0.019	1.1	1.6	2.3
200	0.017	1.0	1.4	2.0

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Case 5: Proposed 120 kV Line as Single Pole Configuration with Distribution Line #204

Figure 27 presents a diagram of the proposed 120 kV transmission line with a vertical phase configuration supported on a single pole structure with the 25 kV distribution underbuild (Line #204). The calculated electric field at the ROW edge is 0.519 kV/m on the two-conductor side and 0.431 kV/m on the single conductor side, with a maximum of 0.543 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is 14.0 mG on the two-conductor side and 13.3 mG on the single conductor side, with a maximum of 18.6 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 20.3 mG on the two-conductor side and 19.2 mG on the single conductor side, with a maximum of 27.1 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 28.1 mG on the two-conductor side and 26.6 mG on the single conductor side, with a maximum of 37.7 mG within the ROW. Figure 28 and Table 28 present graphical and tabular summaries of the electric and magnetic field calculations.

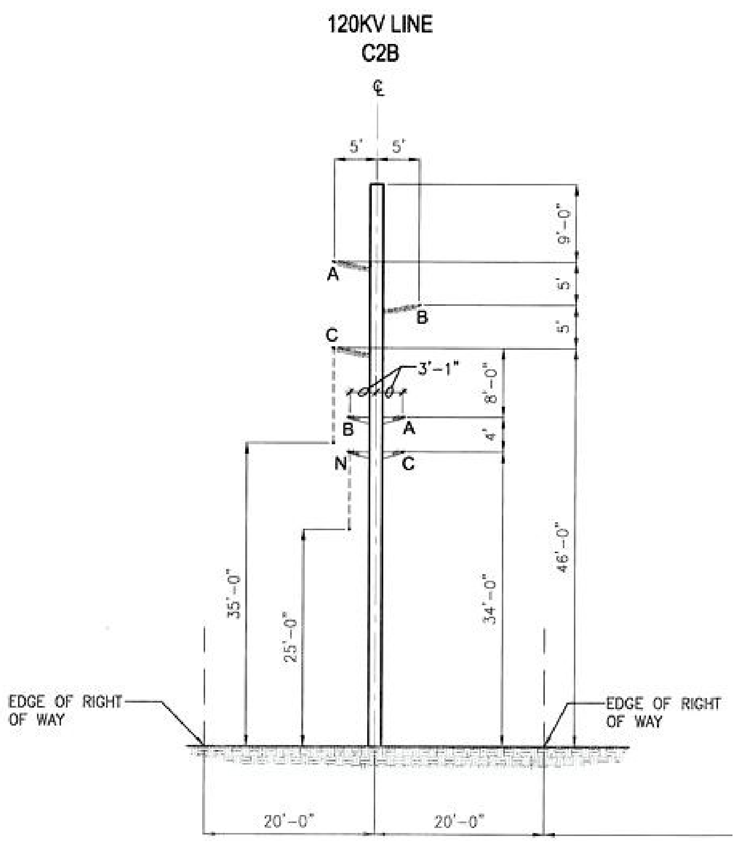
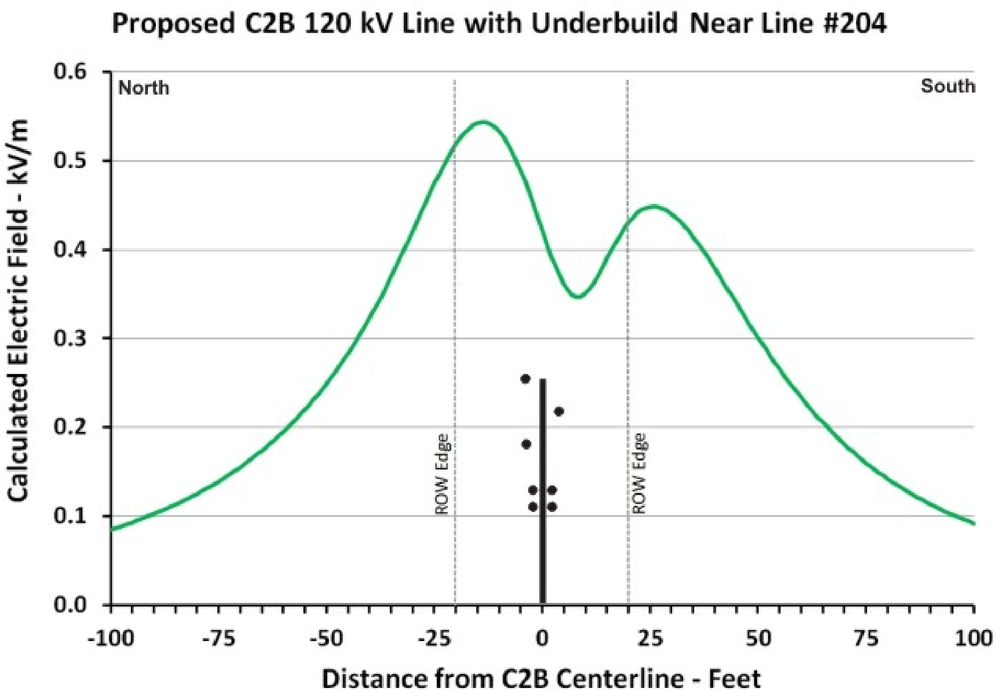


Figure 27
Case 5: Bordertown to California (C2B) Transmission Line Geometry (Single Pole) With Distribution Line #204 (Supplied by NV Energy)



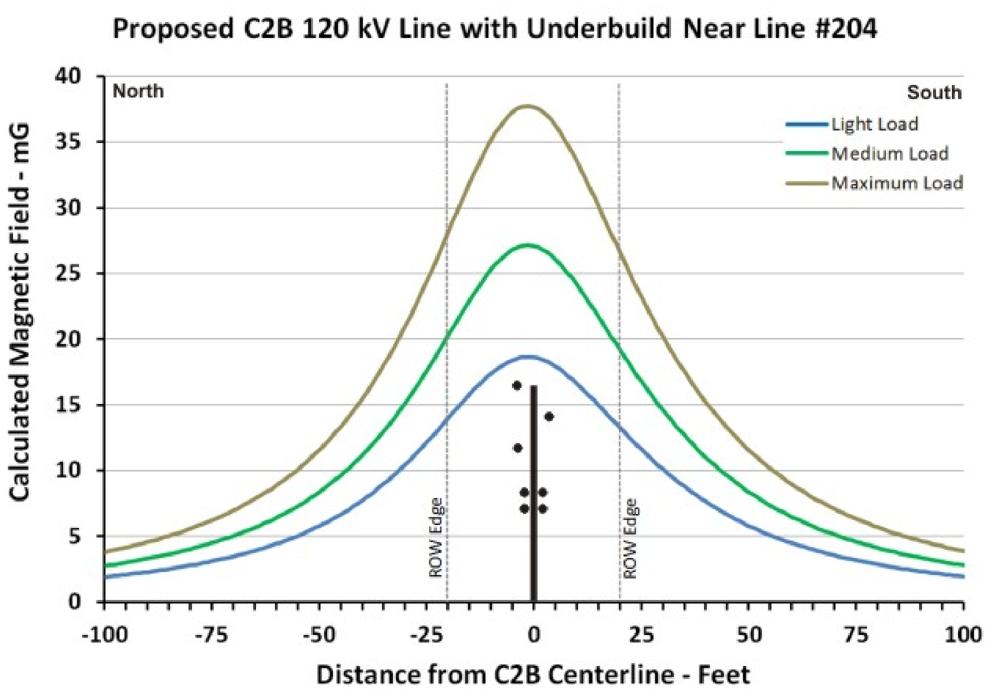


Figure 28
Case 5: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (Single Pole) With Distribution Line #204

Table 28. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with 25 kV Underbuild Line 204

Distance from C2B Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-100	0.085	1.9	2.7	3.8
-90	0.103	2.3	3.3	4.6
-80	0.125	2.8	4.0	5.6
-70	0.155	3.5	5.0	7.0
-60	0.195	4.4	6.4	8.9
-50	0.249	5.8	8.4	11.6
-40	0.323	7.7	11.2	15.5
-30	0.421	10.5	15.1	21.0
-20 - ROW Edge	0.519	14.0	20.3	28.1
-10	0.533	17.4	25.3	35.1
0 – C2B Centerline	0.422	18.6	27.1	37.7
10	0.351	16.6	24.2	33.5
20 - ROW Edge	0.431	13.3	19.2	26.6
30	0.440	10.1	14.6	20.2
40	0.379	7.6	11.0	15.2
50	0.301	5.8	8.4	11.6
60	0.234	4.5	6.5	9.0
70	0.181	3.6	5.1	7.1
80	0.142	2.9	4.1	5.7
90	0.113	2.3	3.4	4.7
100	0.092	2.0	2.8	3.9

Case 6: Proposed 120 kV Line as H-Frame Configuration with Lines #114 & #106

Figure 29 presents a diagram of the proposed 120 kV transmission line with a horizontal phase configuration supported on H-frame structures with the existing Line #106 and Line #114 120 kV transmission lines. This is the line configuration near the Verdi Library and the Verdi Elementary School. Line #632, which is a 120 kV transmission line located closest to the school and library, is inactive (as reported by NV Energy) and not included in the computer model. The calculated electric field at the ROW edge is 0.935 kV/m close to Line #114 and 0.824 kV/m close to the proposed C2B line, with a maximum of 2.943 kV/m within the ROW. Higher electric fields are associated with the proposed C2B line due to lower conductor ground clearances (as shown in Figure 29). For light loading, the calculated magnetic field at the ROW edge is 11.9 mG close to Line #114 and 22.9 mG close to the proposed C2B line, with a maximum of 73.2 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 16.9 mG close to Line #114 and 32.6 mG close to the proposed C2B line, with a maximum of 104.5 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 14.9 mG close to Line #114 and 42.9 mG close to the proposed C2B line, with a maximum of 143.9 mG within the ROW. Figure 30 and Table 29 present graphical and tabular summaries of the electric and magnetic field calculations.

Figure 30 also presents the electric and magnetic field calculation results for the existing Line #114 and Line #106 by themselves for comparison (with day of measurement loading). As shown in this figure, the calculated electric and magnetic field increase near the ROW edge and school property line from existing measured levels due to the presence of the proposed Bordertown to California (C2B) line, which is located on the southern side of the right-of-way closest to the school property line. The location for the proposed C2B line is in about the same location as the location of the existing Line #632, which NV Energy reported as presently not in service.

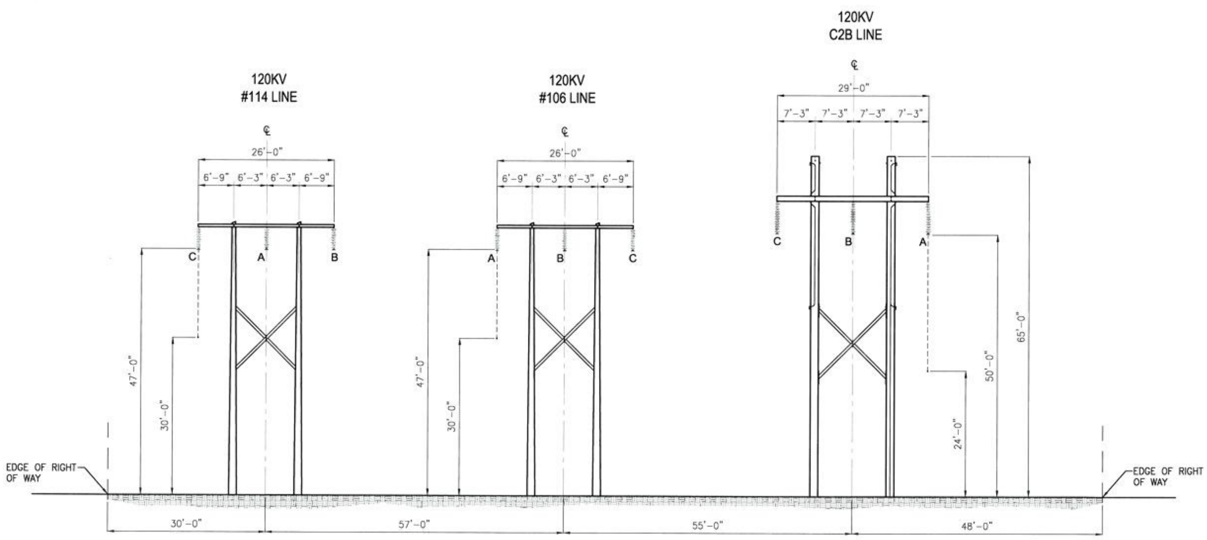
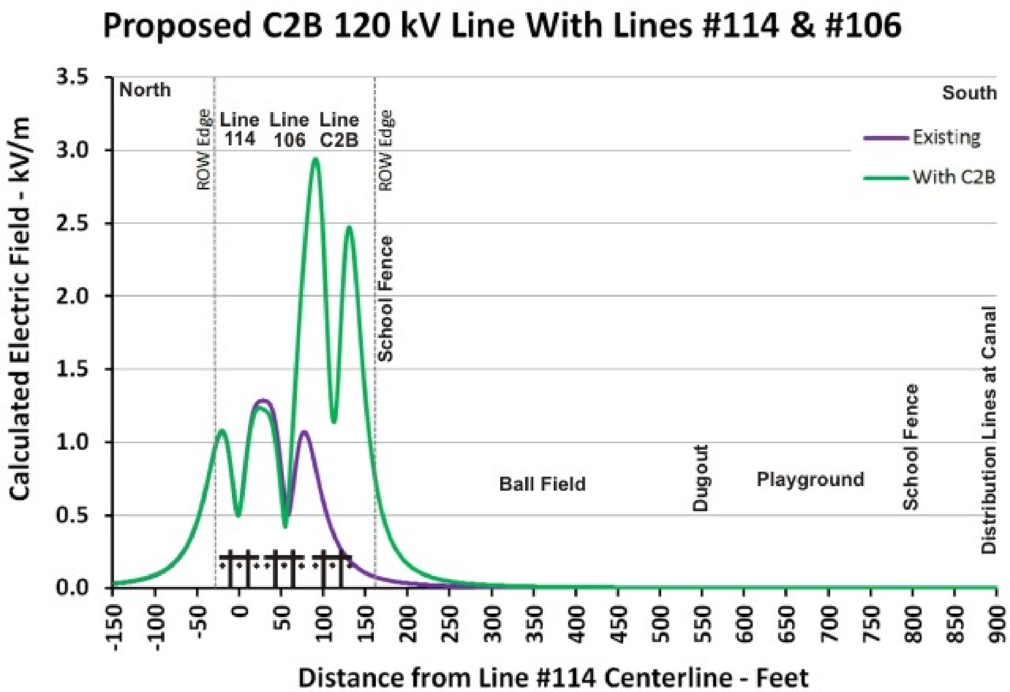


Figure 29
Case 6: Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with Line #114 and Line #106 (Supplied by NV Energy)



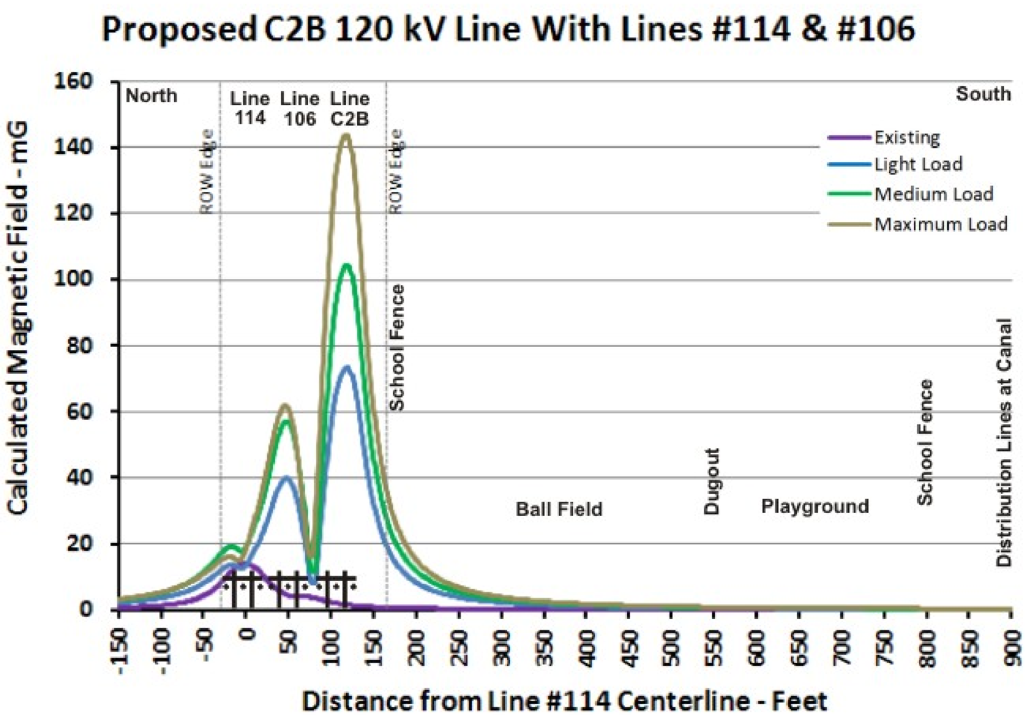


Figure 30
Case 6: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with Line #114 and Line #106 (At Verdi Elementary School and Library)

Table 29. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Lines #114 & #106 at Verdi School & Library

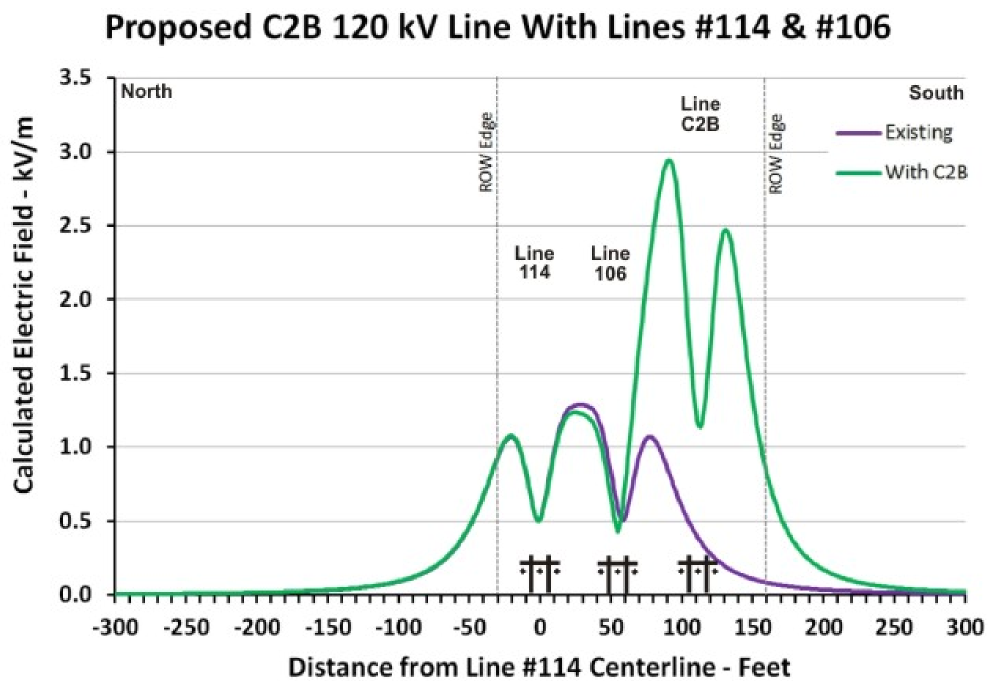
Distance from Transmission Line #114 Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-150	0.032	2.0	2.9	3.1
-140	0.038	2.2	3.2	3.4
-130	0.046	2.5	3.6	3.8
-120	0.057	2.8	4.0	4.2
-110	0.072	3.1	4.5	4.7
-100	0.092	3.6	5.1	5.3
-90	0.120	4.1	5.8	6.0
-80	0.162	4.7	6.7	6.8
-70	0.224	5.6	7.9	7.9
-60	0.318	6.6	9.4	9.2
-50	0.463	8.1	11.4	10.8
-40	0.676	9.9	14.0	12.8
-30 - ROW Edge	0.935	11.9	16.9	14.9
-20	**1.078**	13.4	19.0	16.0
-10	0.832	13.0	18.4	15.0
0 – Line #114 Centerline	0.507	13.4	18.9	18.4
10	0.953	17.9	25.4	27.1
20	**1.220**	23.6	33.6	37.4
30	**1.223**	30.7	43.9	49.2
40	**1.108**	37.8	54.0	59.6
50	0.655	39.7	56.7	60.8
57 – Line #106 Centerline	0.516	36.3	51.8	53.7
60	0.748	33.6	48.0	48.6
70	**1.689**	19.1	27.3	23.6
80	**2.473**	8.0	11.5	21.2
90	**2.935**	30.7	43.8	70.3
100	**2.408**	56.4	80.5	116.7
110	**1.238**	69.6	99.3	138.9
112 – C2B Centerline	**1.145**	70.9	101.2	140.9
120	**1.669**	73.2	104.4	143.4
130	**2.467**	64.5	92.0	124.6
140	**2.059**	46.9	67.0	89.8
150	**1.334**	32.3	46.1	61.3
160 - ROW Edge/School Yard Fence	0.824	22.9	32.6	42.9
170	0.522	16.9	24.1	31.4
180	0.345	12.9	18.4	23.9
190	0.238	10.2	14.6	18.8
200	0.170	8.3	11.9	15.2
210	0.126	6.9	9.8	12.6
220	0.096	5.8	8.3	10.5
230	0.074	5.0	7.1	9.0
240	0.059	4.3	6.1	7.8

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Table 29. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Lines #114 & #106 at Verdi School & Library (Continued)

Distance from Transmission Line #114 Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
250	0.048	3.8	5.4	6.8
260	0.039	3.3	4.7	6.0
270	0.033	3.0	4.2	5.3
280	0.027	2.6	3.8	4.7
290	0.023	2.4	3.4	4.2
300	0.020	2.2	3.1	3.8
310	0.017	2.0	2.8	3.5
320	0.015	1.8	2.6	3.2
330	0.013	1.7	2.4	2.9
340	0.012	1.5	2.2	2.7
350	0.011	1.4	2.0	2.5
360	0.010	1.3	1.9	2.3
370	0.009	1.2	1.7	2.1
380	0.008	1.1	1.6	2.0
390	0.007	1.1	1.5	1.9
400	0.006	1.0	1.4	1.7
410 – Edge of School Building	0.006	0.9	1.3	1.6
420	0.005	0.9	1.2	1.5
430	0.005	0.8	1.2	1.4
440	0.005	0.8	1.1	1.4
450	0.004	0.7	1.0	1.3
460	0.004	0.7	1.0	1.2
470	0.004	0.7	0.9	1.2
480	0.004	0.6	0.9	1.1
490	0.003	0.6	0.9	1.0
500	0.003	0.6	0.8	1.0
550 – Ball Field Dugout/Bleachers	0.002	0.5	0.6	0.8
600	0.002	0.4	0.5	0.6
670 – Basketball Court	0.001	0.3	0.4	0.5
700	0.001	0.3	0.4	0.4
800 – School Fence Near Residence	0.001	0.2	0.3	0.3
820 – Edge of Power House Road	0.001	0.2	0.3	0.3
840 – Edge of Power House Road	0.001	0.2	0.2	0.3
900 – Edge of Canal	0.001	0.2	0.2	0.3

Figure 31 presents the electric and magnetic field calculations for the same configuration (the proposed 120 kV transmission line with existing Line #106 and Line #114) as was measured in the residential neighborhoods of Verdi (Line #632 is not included in the computer model). The calculated electric and magnetic field levels at the ROW edge and within the ROW remain the same as the modeling configuration remains unchanged.



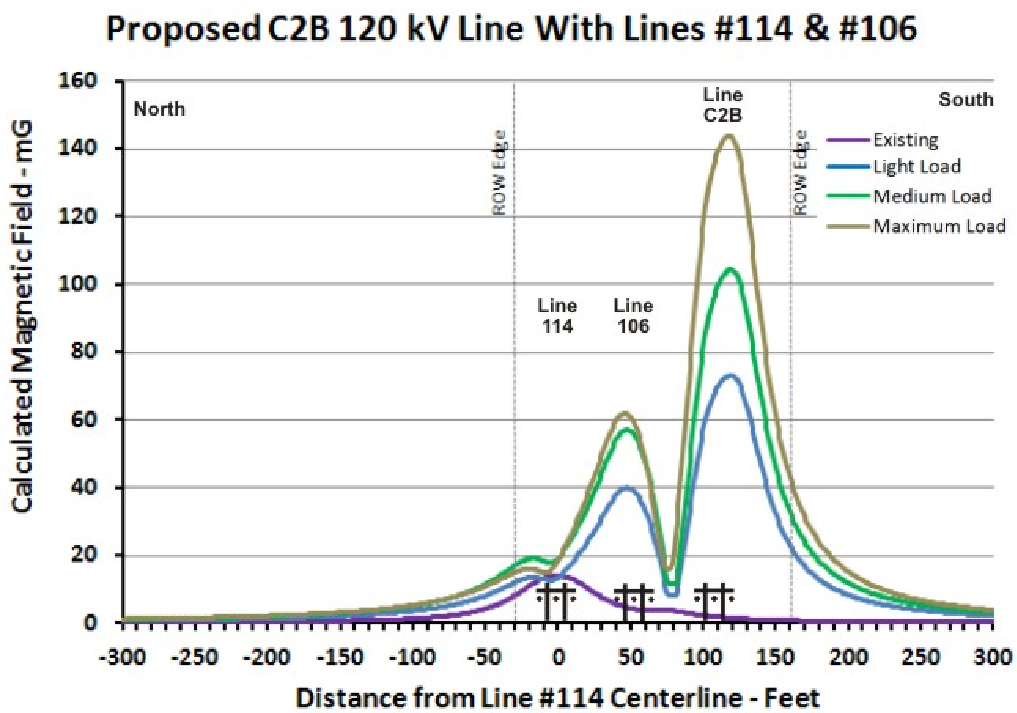


Figure 31
Case 6: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (H-Frame) with Line #114 and Line #106 (In Verdi Residential Neighborhoods)

Table 30. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Lines #114 & #106 in Verdi Residential Areas

Distance from Transmission Line #114 Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-300	0.006	0.7	1.0	1.1
-290	0.006	0.7	1.1	1.2
-280	0.007	0.8	1.1	1.3
-270	0.007	0.8	1.2	1.3
-260	0.008	0.9	1.3	1.4
-250	0.009	0.9	1.3	1.5
-240	0.010	1.0	1.4	1.6
-230	0.011	1.1	1.5	1.7
-220	0.012	1.2	1.6	1.8
-210	0.013	1.2	1.8	2.0
-200	0.015	1.3	1.9	2.1
-190	0.017	1.4	2.1	2.3
-180	0.020	1.6	2.2	2.4
-170	0.023	1.7	2.4	2.6
-160	0.027	1.9	2.6	2.9
-150	0.032	2.0	2.9	3.1
-140	0.038	2.2	3.2	3.4
-130	0.046	2.5	3.6	3.8
-120	0.057	2.8	4.0	4.2
-110	0.072	3.1	4.5	4.7
-100	0.092	3.6	5.1	5.3
-90	0.120	4.1	5.8	6.0
-80	0.162	4.7	6.7	6.8
-70	0.224	5.6	7.9	7.9
-60	0.318	6.6	9.4	9.2
-50	0.463	8.1	11.4	10.8
-40	0.676	9.9	14.0	12.8
-30 - ROW Edge	0.935	11.9	16.9	14.9
-20	**1.078**	13.4	19.0	16.0
-10	0.832	13.0	18.4	15.0
0 – Line #114 Centerline	0.507	13.4	18.9	18.4
10	0.953	17.9	25.4	27.1
20	**1.220**	23.6	33.6	37.4
30	**1.223**	30.7	43.9	49.2
40	**1.108**	37.8	54.0	59.6
50	0.655	39.7	56.7	60.8
57 – Line #106 Centerline	0.516	36.3	51.8	53.7
60	0.748	33.6	48.0	48.6
70	**1.689**	19.1	27.3	23.6
80	**2.473**	8.0	11.5	21.2
90	**2.935**	30.7	43.8	70.3
100	**2.408**	56.4	80.5	116.7

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Table 30. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line with Lines #114 & #106 in Verdi Residential Areas (Continued)

Distance from Transmission Line #114 Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
110	**1.238**	69.6	99.3	138.9
112 – C2B Centerline	**1.145**	70.9	101.2	140.9
120	**1.669**	73.2	104.4	143.4
130	**2.467**	64.5	92.0	124.6
140	**2.059**	46.9	67.0	89.8
150	**1.334**	32.3	46.1	61.3
160 - ROW Edge	0.824	22.9	32.6	42.9
170	0.522	16.9	24.1	31.4
180	0.345	12.9	18.4	23.9
190	0.238	10.2	14.6	18.8
200	0.170	8.3	11.9	15.2
210	0.126	6.9	9.8	12.6
220	0.096	5.8	8.3	10.5
230	0.074	5.0	7.1	9.0
240	0.059	4.3	6.1	7.8
250	0.048	3.8	5.4	6.8
260	0.039	3.3	4.7	6.0
270	0.033	3.0	4.2	5.3
280	0.027	2.6	3.8	4.7
290	0.023	2.4	3.4	4.2
300	0.020	2.2	3.1	3.8

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Case 7: Proposed 120 kV Line as Single Pole Configuration with Alturas 345 kV

The proposed C2B 120 kV transmission line would be located 60-feet south of the Alturas line (centerline to centerline). This proposed route locates the proposed C2B along North Virginia Street close to the Alturas line and in front of the residence. Figure 32 presents a diagram of the proposed 120 kV transmission line 60-feet south of the existing Alturas 345 kV transmission line. The proposed C2B line is arranged in a vertical phase configuration supported on a single pole structure with a distribution underbuild. For the existing Alturas 345 kV transmission line, the southern right-of-way edge is now shared with the northern right-of-way edge of the proposed C2B 120 kV transmission line (as a common ROW edge).

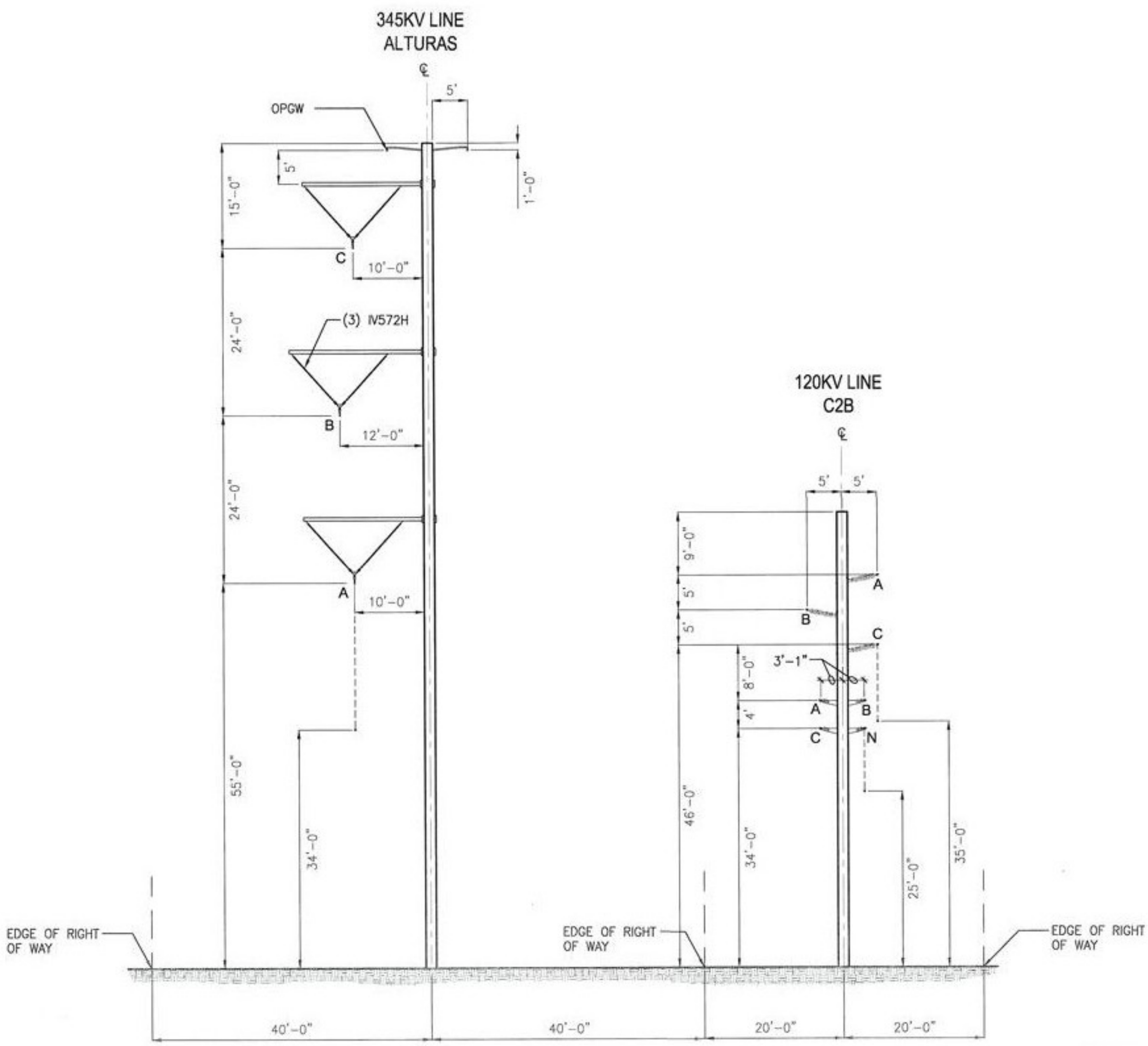


Figure 32
Case 7: Bordertown to California (C2B) Transmission Line Geometry (Single Pole) with Underbuild at 60-Feet South of the Alturas 345 kV Transmission Line at North Virginia Street

For the Alturas 345 kV right-of-way, the calculated electric field at the ROW edge is 2.064 kV/m for the conductored side and 0.673 kV/m for the non-conductored side of Alturas 345 kV line, with a maximum of 5.276 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is 13.0 mG for the conductored side and 21.5 mG for the non-conductored side of the Alturas 345 kV line, with a maximum of 22.3 within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 19.2 mG for the conductored side and 31.1 mG for the non-conductored side of the Alturas 345 kV line, with a maximum of 32.8 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 6.6 mG for the conductored side and 25.3 mG for the non-conductored side of the Alturas 345 kV line, with a maximum of 25.3 mG within the ROW (due to the presence of the adjacent C2B 120 kV line under maximum loading conditions). As noted in Table 23, the loading for the Alturas 345 kV transmission line is lower when the loading on the proposed C2B line is at a maximum loading condition.

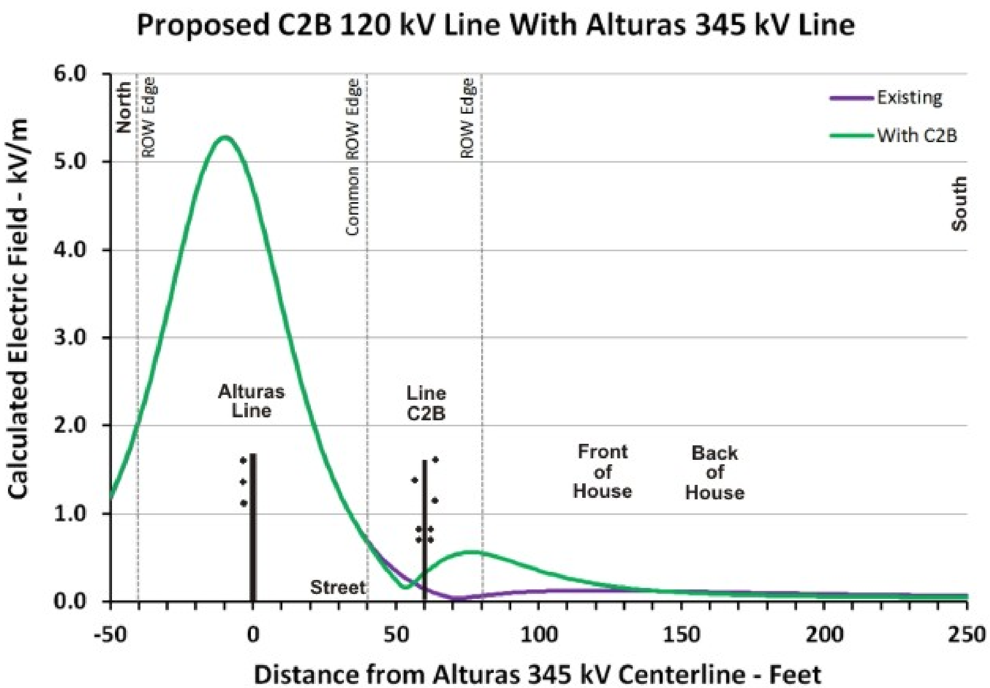
For the proposed Bordertown to California (C2B) 120 kV right-of-way, the calculated electric field at the ROW edge is 0.673 kV/m for the single conductor side and 0.551 kV/m for the two conductor side of the line, with a maximum of 0.673 kV/m within the ROW. For light loading, the calculated magnetic field at the ROW edge is 21.5 mG for the single conductor side and 12.3 mG for the two conductor side of the C2B 120 kV line, with a maximum of 23.1 mG within the ROW. For medium loading, the calculated magnetic field at the ROW edge is 31.1 mG for the single conductor side and 17.6 mG for the two conductor side of the C2B 120 kV line, with a maximum of 33.3 mG within the ROW. For maximum loading, the calculated magnetic field at the ROW edge is 25.3 mG for the single conductor side and 26.6 mG for the two conductor side of the C2B 120 kV line, with a maximum of 35.5 mG within the ROW.

Figure 33 and Table 31 present graphical and tabular summaries of the electric and magnetic field calculations. Figure 33 also presents the electric and magnetic field calculation results for the existing Alturas 345 kV line by itself for comparison (with day of measurement loading). At this North Virginia Street location with the 60-feet distance separation, the residence would be located south of both the Alturas 345 kV transmission line and the proposed Bordertown to California (C2B) transmission line (which would be routed along North Virginia Street).

Table 31. Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Line at 60-Feet South of the Alturas 345 kV Line at North Virginia Street

Distance from Alturas 345 kV Transmission Centerline (Feet)	Unperturbed Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
-50	**1.193**	10.3	15.2	5.7
-40 - ROW Edge Alturas	**2.064**	13.0	19.2	6.6
-30	**3.306**	16.4	24.1	7.5
-20	**4.637**	19.8	29.1	8.0
-10	**5.276**	22.0	32.4	7.8
0 - Alturas Centerline	**4.678**	22.1	32.5	7.5
10	**3.369**	20.9	30.6	8.6
20	**2.130**	19.8	28.9	12.0
30	**1.251**	19.9	28.9	17.7
40 - ROW Edge Alturas & C2B Line	0.673	21.5	31.1	25.3
50	0.245	23.1	33.3	32.9
60 - C2B Centerline	0.318	21.5	30.8	35.4
70	0.526	17.0	24.3	32.1
80 - Row Edge C2B Line	0.551	12.3	17.6	26.6
90	0.461	8.5	12.1	20.9
100	0.355	5.8	8.2	16.1
110	0.268	3.9	5.6	12.4
120 – Front of Residence	0.203	2.8	3.9	9.7
130	0.157	2.1	2.9	7.7
140	0.125	1.6	2.3	6.2
150	0.103	1.3	1.9	5.1
160 – Back of Residence	0.088	1.1	1.6	4.3
170	0.078	0.9	1.3	3.6
180	0.070	0.8	1.2	3.1
190	0.065	0.7	1.0	2.7
200	0.060	0.6	0.9	2.4
210 – End of Driveway	0.057	0.6	0.8	2.1
220	0.053	0.5	0.7	1.8
230	0.050	0.4	0.6	1.6
240	0.048	0.4	0.6	1.5
250	0.045	0.4	0.5	1.3

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.



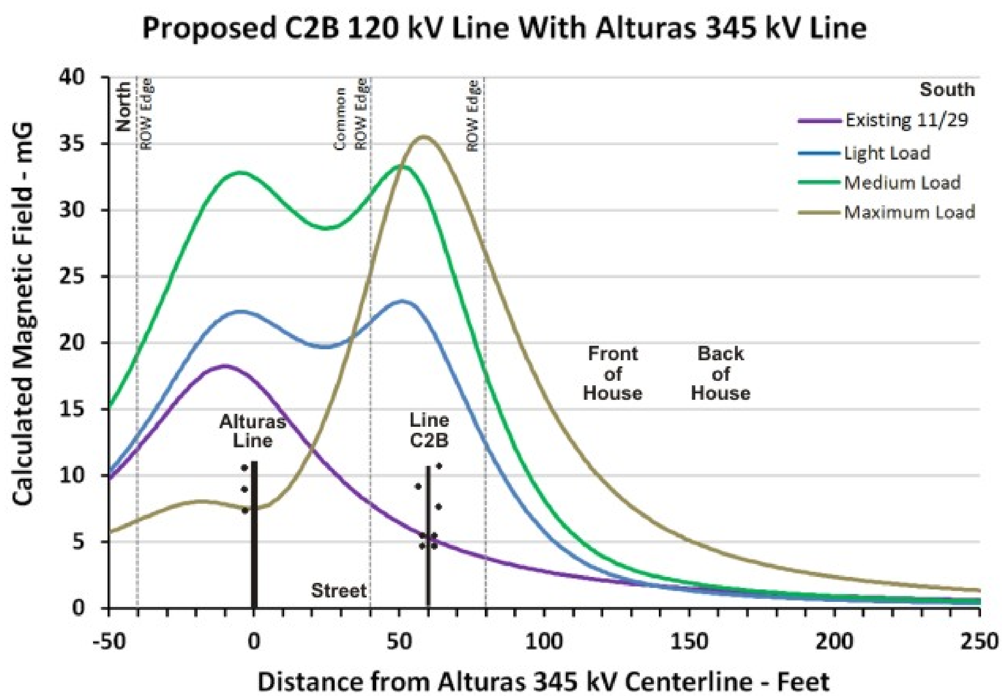


Figure 33
Case 7: Calculated Electric and Magnetic Fields for the Proposed Bordertown to California (C2B) Transmission Line Geometry (Single Pole) with Underbuild at 60-Feet South of the Alturas 345 kV Transmission Line at North Virginia Street

Section 4. Environmental Consequences

In order to evaluate environmental consequences for various route alternatives, a basis is required for establishing the magnitude and duration of electric and magnetic field impacts. As described in Section 2, in the absence of federal and state EMF standards based on avoiding a health hazard at environmental exposure levels, various non-governmental organizations have established or recommended health-based exposure limits, including the American Conference of Governmental Industrial Hygienists (ACGIH 2012), the International Commission on Non-Ionizing Radiation Protection (ICNIRP 2010), and the Institute of Electrical and Electronics Engineers (IEEE 2002). Of these organizations, the lowest thresholds for electric and magnetic fields are those published by the ACGIH for workers with cardiac pacemakers (1 kV/m for AC electric fields and 1,000 mG for AC magnetic fields). Therefore, for purposes of this study, Enertech was asked to evaluate the magnitude of potential environmental effects by using the ACGIH levels as the criteria for the following thresholds:

Table 32. Definitions for Environmental Effects Based Upon the ACGIH Occupational Threshold Levels for Workers with Implanted Medical Devices

Magnitude	ACGIH Threshold Level	
	Electric Field (1 kV/m)	Magnetic Field (1,000 mG)
Major: Exceeds ACGIH Levels	> 1 kV/m	> 1,000 mG
Modest: 25 to 100% of ACGIH Levels	0.25 to 1 kV/m	250 to 1,000 mG
Minor: Under 25% of ACGIH Levels	< 0.25 kV/m	< 250 mG

Negligible changes in environmental levels are those that create change from the existing field conditions that are close to zero or no greater than minute-by-minute fluctuations during normal operation. Duration levels were defined as Temporary (occurring during construction and maintenance activities), Short-Term (10 years or less), and Long-Term (more than 10 years).

Alternative 1 – No Action

Alternative 1 is the scenario where the proposed Bordertown to California (C2B) 120 kV transmission line is not constructed. For this scenario, electric and magnetic field levels would remain unchanged from existing conditions due to the presence of the various existing transmission lines, as the proposed line would not be introduced.

Magnitude: Negligible for Electric and Magnetic Fields
Duration: Long-Term

Effects Common to All Action Alternatives

Alternatives 2 through 7 would include a portion of the proposed line route with the Bordertown to California (C2B) 120 kV transmission line by itself. All scenarios would include the proposed line in an H-frame configuration by itself and many would include the proposed 120 kV line with a distribution underbuild. In addition, all of the alternatives share the proposed 120 kV line route adjacent to the existing Alturas 345 kV H-frame transmission line south of the Bordertown Substation.

For the proposed H-frame 120 kV configuration, these locations would not have existing transmission or distribution lines present; therefore, the introduction of the proposed 120 kV transmission line would create new electric and magnetic field where none previously existed. Calculated electric fields would increase to about 0.964 kV/m at the right-of-way edges and to 2.499 kV/m within the right-of-way. Calculated magnetic fields would increase to about 21.5 mG at the right-of-way edges for light loading, 30.7 mG for medium loading, and 42.0 mG for maximum loading. Within the right-of-way, calculated magnetic fields would increase to about 77.3 mG for light loading, 110.3 mG for medium loading, and 150.7 mG for maximum loading.

Magnitude: Modest at ROW Edges, Major within the ROW for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

For the proposed single pole 120 kV configuration with a 25 kV underbuild, these locations would not have existing transmission or distribution lines present; therefore, the introduction of the proposed 120 kV transmission line would create new electric and magnetic field where none previously existed. Calculated electric fields would increase to about 0.431 to 0.519 kV/m at the right-of-way edges and to 0.543 kV/m within the right-of-way. Calculated magnetic fields would increase to about 13.2 mG to 13.9 mG at the right-of-way edges for light loading, to 18.9 mG to 19.9 mG for medium loading, and 26.0 mG to 27.6 mG for maximum loading. Within the right-of-way, calculated magnetic fields would increase to about 18.5 mG for light loading, 26.3 mG for medium loading, and 36.6 mG for maximum loading.

Magnitude: Modest for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

For the existing Alturas 345 kV transmission line south of the Bordertown Substation, the proposed C2B 120 kV transmission line would be located 200-feet away (centerline to centerline) within its own right-of-way. Due to this distance separation, electric and magnetic fields from the proposed C2B 120 kV transmission line would not significantly influence the existing Alturas 345 kV transmission line, and vice versa. Therefore, the overall change in electric and magnetic fields would be the same as introducing the proposed C2B line by itself.

Magnitude: Modest at ROW Edges, Major within the ROW for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

Alternatives 2, 3, and 4 (Stateline, Mitchell, and Peavine Alternatives)

In addition to the three common transmission line right-of-way configurations previously discussed, Alternatives 2 (the Proposed Action Stateline Alternative), 3 (the Mitchell Alternative), and 4 (the Peavine Alternative) all share two other common transmission line routing configurations:

- Proposed C2B 120 kV Line with existing Line #102 120 kV Transmission Line
- Proposed C2B 120 kV Line with existing distribution line #204

For the existing Line #102 120 kV transmission line north of the California Substation near Henness Pass Road, the proposed C2B 120 kV transmission line would be located 110-feet away from the existing line within its own right-of-way. Electric and magnetic field levels from Line #102 would be influenced by and increase on the side of the transmission line closest to proposed C2B 120 kV transmission line. Calculated electric fields from Line #102 within the right-of-way would increase from about 1.085 kV/m to 1.210 kV/m due to the presence of the proposed C2B line. Similarly, calculated electric fields due to the presence of the proposed C2B line within the right-of-way would increase slightly from about 2.499 kV/m to 2.563 kV/m on the side towards the existing Line #102. For magnetic fields, similar increases are present due to each of the lines influence, with the maximum magnetic field levels increasing slightly near the proposed C2B line from 77.3 mG to 79.0 mG for light loading, from 110.3 mG to 112.8 mG for medium loading and 150.7 mG to 153.2 mG for maximum loading. However, calculated field levels decrease slightly at the proposed C2B line right-of-way edge (for electric fields, 0.964 kV/m decreases to 0.956; for magnetic fields, 21.5 mG decreases to 20.8 mG for light loading and 30.7 mG decreases to 29.6 mG for medium loading, and 42.0 mG decreases to 40.8 mG for maximum loading). Essentially, the overall change in electric and magnetic fields would be the same as introducing the proposed C2B line by itself (due to the distance separation from the existing Line #102, with some field interaction in the area between the two lines).

Magnitude: Modest at ROW Edges, Major within the ROW for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

For the existing distribution line #204 north of the California Substation near Henness Pass Road, this circuit would be reconstructed as the 25 kV underbuild with the proposed C2B line (as a single pole configuration with a 25 kV distribution underbuild). The calculated electric field at is 0.431 to 0.519 kV/m at the ROW edges and 0.543 kV/m within the ROW. For light loading, the calculated magnetic field is 13.3 to 14.0 mG at the right-of-way edges for light loading, 19.2 to 20.3 mG for medium loading, and 26.6 to 28.1 mG for maximum loading. Within the right-of-way, calculated magnetic fields are about 18.6 mG for light loading, 27.1 mG for medium loading, and 37.7 mG for maximum loading.

Magnitude: Modest for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

The routing for these three alternatives (the Proposed Action Stateline Alternative, the Mitchell Alternative, and the Peavine Alternative), however, appear to have the least amount of line route through existing populated and residential areas. These three transmission line routes cross the northwestern edge of Verdi as they are routed into the California Substation. In this area, there are scattered residential developments. The other three alternative line routes under consideration (the Poevine Alternative, the Stateline/Poevine Alternative, and the Peavine/Poevine Alternative), all cross through the town of Verdi, within residential areas, and adjacent to the Verdi Elementary School and Library.

Alternative 5 (Poeville Alternative)

In addition to the three common transmission line right-of-way configurations previously discussed, Alternative 5 (the Poevine Alternative) would have two other transmission line routing configurations:

- Proposed C2B 120 kV Line with existing #114/#106/#632 120 kV lines
- Proposed C2B 120 kV Line with existing Alturas 345 kV and distribution line #257

The three existing 120 kV transmissions, Line #114, Line #106, and Line #632, are located within adjacent right-of-ways next to the Verdi Library and Elementary School, as well as within residential neighborhoods in the local area. As previously noted, Line #632 is presently not in service, has no field contribution, and was excluded from the modeling analysis.

The Bordertown to California (C2B) line is proposed to be located south of the existing Line #106 (reference Figure 29), which is about in the same location as the existing Line #632 (presently not in service). This arrangement locates the proposed C2B line closest to the Verdi Elementary School property line and the Verdi Library. Since the existing Line #632 is not in service, locating the proposed C2B line near the same location would increase electric and magnetic fields along the right-of-way edge adjacent to the school and library. The calculated electric field at the ROW edge is 0.824 kV/m near the school property line, while the calculated magnetic field is 22.9 mG under light loading, 32.6 mG under medium loading, and 42.9 mG under maximum loading. These levels are increased from measured values of about 0.096 kV/m for electric fields and about 0.5 mG for magnetic fields (under day of measurement loading conditions). At the edge of the closest school building (410-feet from Line #114), the measured electric field of 0.000 kV/m increases to a calculated level of 0.006 kV/m, and the measured magnetic field of 0.2 mG (under day of measurements loading)) increases to a calculated level of 0.9 mG under light loading, 1.3 mG under medium loading, and 1.6 mG under maximum loading conditions. Since the day of measurements loading (Line #114 was about 77 A, Line #106 was about 26 A) is significantly lower than the light, medium, and maximum loading conditions reported by NV Energy (Line #114 as 90A/127A/75A, Line #106 as 280A/400A/429A respectively), measured magnetic field levels would also be correspondingly lower even without the inclusion of the proposed C2B line.

At the northern ROW edge closest to Line #114, the calculated electric field would remain unchanged. Magnetic field could increase, depending upon the loading of Line #114 and Line #106 in relation to the proposed C2B line. However, the existing 120 kV lines will be the primary magnetic field source along this northern ROW edge and not the proposed C2B line.

Magnitude: Modest at ROW Edges, Major within the ROW for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

For the existing Alturas 345 kV transmission line and distribution line #257 at North Virginia Street, the proposed C2B 120 kV transmission line could be located 60-feet away from the Alturas line along North Virginia Street. Electric and magnetic fields from the proposed C2B 120 kV line could increase from existing levels, depending upon the location of the residence with respect to North Virginia Street. The dominant source of electric and magnetic fields for residences close to North Virginia Street would become a combination of the existing Alturas 345 kV transmission line and the proposed C2B 120 kV line.

Magnitude: Modest for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

Alternatives 6 and 7 (Stateline/Poeville and Peavine/Poeville Alternatives)

In addition to the three common transmission line right-of-way configurations previously discussed, Alternatives 6 (the Stateline/Poevine Alternative) and 7 (the Peavine/Poevine Alternative) would share a common transmission line routing configuration previously discussed with Alternative 5:

- Proposed C2B 120 kV Line with existing #106/#114/#632 120 kV lines

As previously discussed, the Bordertown to California (C2B) line is proposed to be located adjacent to and along the southern right-of-way boundary of existing Line #114 and Line #106 (about in the same location as the existing Line #632 presently not in service). At the ROW edge closest to Line #114, the calculated electric field would remain unchanged. Magnetic field could increase, depending upon the loading of Line #114 and Line #106 in relation to the proposed C2B line. However, the existing 120 kV lines will be the primary magnetic field source along this northern ROW edge and not the proposed C2B line. At the ROW edge closest to the proposed C2B line, calculated electric and field levels would increase, since the existing Line #632 is presently not in service. The proposed C2B 120 kV line would become the primary electric and magnetic field source along this southern ROW edge, with calculated electric field levels of 0.824 kV/m and magnetic field levels of 22.9 mG under light loading, 32.6 mG under medium loading, and 42.9 mG under maximum loading conditions.

Magnitude: Modest at ROW Edges, Major within the ROW for Electric Fields
Minor for Magnetic Fields (Light, Medium, and Maximum Loading)
Duration: Long-Term

Standards Compliance

Section 2 presents a discussion of electric and magnetic field standards. As noted in this section, presently there are no state or federal health-based standards for limiting exposure to these fields. However, non-regulatory exposure limits have been established or recommended by several different organizations such as the American Conference of Governmental Industrial Hygienists, the International Commission on Non-Ionizing Radiation Protection, and the Institute of Electrical and Electronics Engineers. The measured and calculated electric and magnetic field levels associated with the proposed C2B 120 kV transmission line are near or below recommended levels cited by these organizations beyond the transmission line right-of-way. Within the right-of-way, calculated electric fields exceed the 1 kV/m threshold recommended by the ACGIH for persons with implanted medical devices (ACGIH 2012). Existing transmission lines, such as the Alturas 345 kV line, may also presently exceed this non-regulatory threshold.

For both the H-frame and single pole configurations, calculated electric and magnetic field levels are below the thresholds for other states with engineering standards, both within the right-of-way and at the right-of-way edges.

Optional Field Reduction Techniques

This section presents optional techniques for reducing magnetic fields from transmission lines. These are techniques which could be implemented for field reduction; however, none of these techniques are required, recommended, or proposed for the C2B transmission line project.

H-Frame versus Single Pole Configuration

In most locations, the proposed C2B line is located either by itself or sufficiently far away from other existing transmission lines that the proposed line creates its own electric and magnetic fields and does not significantly influence fields from other existing lines. In these circumstances, the H-frame configuration produces higher electric and magnetic field levels than the single pole vertical configuration (without the 25 kV underbuild), as demonstrated in Table 33. In addition, a 90-foot wide right-of-way is specified for the H-frame configuration, while a smaller 40-foot wide right-of-way is specified for the single pole vertical configuration. If the single pole configuration is utilized within the H-frame configuration right-of-way width (of 90-feet), then the increased width reduces both electric and magnetic field levels at the right-of-way edges. Finally, utilization of the single pole design reduces field levels within the right-of-way.

Table 33. Comparison of Electric and Magnetic Field Calculations for Proposed Bordertown to California (C2B) 120 kV Configurations

Configuration Type and Field Calculation Location	Electric Field (kV/m)	Magnetic Field (mG)		
		Light Load	Medium Load	Maximum Load
ROW Edges:				
H-Frame at +/-45’	0.964	21.5	30.7	42.0
Single Pole at +/-20’	0.758/0.616	12.4/12.0	17.7/17.1	
Single Pole at +/-45’	0.324/0.373	6.1	8.7	
Maximum on ROW:				
H-Frame Configuration	**2.499**	77.3	110.3	150.7
Single Pole Configuration	0.892	16.0	22.9	

Note: Bold values exceed the 2012 ACGIH threshold for workers with implanted medical devices.

Other Reduction Options

Various other field reduction options can be implemented to reduce electric and magnetic fields from transmission lines. These options would typically be expensive and require the authorization, approval, and implementation of the local electric utility:

- Increased Right-of-Way Width
- Line Relocation
- Increased Line Height
- Optimal Phasing Arrangement
- Split-Phase Arrangement of Conductors
- Line Compaction
- Undergrounding an Overhead Line

Increasing the right-of-way width involves the purchase of additional land in order to increase the distance away from the transmission line. Often, this option cannot be implemented because land adjacent to the right-of-way has already been developed and is not available for expansion of the right-of-way.

Line relocation would involve the selection of a new alternative line route. Because there are six different line routes under consideration, this option may include the selection of an alternative route or the creation of a new alternative route.

Increased line height involves raising the conductors higher in elevation to minimize field levels near the line. This mitigation option requires taller support structures, which may or may not be aesthetically feasible or practical (for example, near airports).

Optimal phasing arrangements are typically utilized on double circuit transmission lines where two circuits share a common support structure. Since the proposed C2B line would be located on a separate set of structures and not be shared with any other existing lines (on the same structures in a double circuit configuration), this option would not produce field reduction for this situation. In locations where the proposed C2B line is routed near other existing transmission lines, the distance separation between transmission lines can also render this option relatively ineffective if the distance is significant. However, where the proposed C2B line is routed in close proximity to other existing transmission lines (for example, in Verdi near the Library and the Elementary School or at the North Virginia Street location with the project line 60-feet away from the existing Alturas line), there is a possibility that a different phasing arrangement may be more efficient for increasing field cancellation. However, a more detailed modeling effort would be required to determine what additional field reduction might be achieved (if any) under different phasing configurations.

The mitigation option for a split-phase arrangement involves doubling the number of conductors (two conductors per phase) and creating a double circuit transmission line from a single circuit design. When this is performed, the loading is split between the two phases and the phases can be arranged in an optimum phasing arrangement to increase field cancellation. Implementation of this option would require support structures capable of a double circuit design and doubling the amount of conductors (wires) being supported. This mitigation option may be implemented for very short sections of line route but is impractical and cost-prohibitive to implement over long sections of line.

Line compaction is utilized if the energized conductors can be located closer together on a structure, thereby increasing field cancellation between phases. Typically transmission lines are engineered and designed to ensure proper spacing between phases and to avoid arcing and/or flash-over in compliance with the National Electric Safety Code (NESC 2012). Therefore, this mitigation option has limited application.

Relocating an overhead line underground requires the construction of transition towers at each end of the line route where undergrounding occurs. While locating a transmission line underground eliminates the electric field versus an overhead line, there is still a magnetic field presence. Directly above an underground line, magnetic fields will typically be higher than for a similar overhead line (due to the reduced distance away from the current-carrying conductors). However, the magnetic field will decrease more quickly with distance away from the line (due to the closer proximity of the three phase conductors). Magnetic fields are also significantly increased at the location of the transition towers, where the overhead conductors are routed vertically down the structures to below ground level. Relocating an overhead section of transmission line underground increases costs versus overhead lines due to the addition of transition towers, underground vault installations, trenching, cable purchase and maintenance costs, and associated construction expenses. In addition, the greater difficulty of maintenance on underground lines than for overhead lines may reduce reliability and lengthen outage durations.

Regardless of the mitigation option considered, all transmission lines must be constructed in accordance with the National Electric Safety Code (NESC 2012) for safeguarding of persons from hazards arising from the installation, operation, or maintenance of electric supply stations and electric supply lines. Other state and local regulations and ordinances may also apply. In addition, electric utilities will also design transmission and distribution lines with maintenance safety and reliability factors.

Section 5. Scientific Information from Health Studies and Evaluation of Public Meeting Inquiries

Potential health effects of power line EMFs have been studied for over 45 years. Research has investigated the health of workers exposed at high levels over years of work, adults and children exposed at home, and people living near power lines of various types. A large amount of understanding has been gained from experimental and analytic research that can be condensed into these summary statements (Lefcourt, A.M. (ed.) 1991; NIEHS 1998; IARC 2002; NIEHS 2002; World Health Organization 2007):

- studies of people and of laboratory animals have not given conclusive evidence for adverse health effects from power line EMFs, particularly at levels found in residential and public environments;
- scientific analysis based on the physics and biology of EMFs, cells, tissues, and whole organisms shows there is no reasonable possibility of biological effects at levels encountered by the public;
- epidemiologic studies among the small fraction of children exposed in homes where magnetic fields are above approximately 3 to 4 mG have not been able to conclude if an increase in the risk of childhood leukemia observed in a number of studies is true or erroneous despite a decades-long worldwide effort; a smaller body of epidemiologic evidence has raised questions about EMF exposure to adults in association with risks of leukemia, brain cancer and neurodegenerative diseases;
- in respect of unresolved and inconclusive evidence concerning childhood leukemia and residential magnetic fields, a UN public health agency classified power frequency magnetic fields as a possible cause of cancer (IARC 2002), and an earlier scientific review conducted by a U.S. health agency came to a similar conclusion (NIEHS 1998);
- research shows no health effects in large animals such as cattle and sheep living near power lines;
- guidelines for public exposure to power line EMFs exist to provide a high degree of safety from possible interference with nervous system functions, and the undoubted hazards of electric shock;
- in the absence of any definite excess risk attributable to power lines, there are no federal standards for power line EMFs, and those states, such as California, that have incorporated EMF science into regulatory procedures did not base their rules on avoidance of specific health risks.

Although for the purposes of this report the depth of information taken from the scientific literature is necessarily limited, the treatment that follows illustrates certain topics that have been examined more closely by the scientific community in addressing the potential for adverse health effects, and also gives further understanding of the scientific basis for existing health and safety standards and guidelines.

Assessments of Scientific Research on EMF Health Risks

Potential health effects of power-frequency EMF have been studied for over 45 years, allowing detailed understanding on many scientific topics, but a few health questions remain unresolved. Early on, the health of utility workers exposed to strong electric fields near high-voltage equipment was of concern, but the primary questions that drive public and scientific interest today are whether leukemia is more common among children living in homes with higher levels of magnetic field exposure, and, to lesser degree, whether neurodegenerative diseases such as Alzheimer Disease and ALS (amyotrophic lateral sclerosis, “Lou Gehrig Disease”) are more common with long-term, high-level, EMF exposure, particularly in occupational settings.

The questions about childhood leukemia and neurodegenerative diseases come from epidemiologic research in which the health of people exposed to EMFs at home or on the job was studied using statistical techniques, that is, by observation rather than experiment. Epidemiologic research makes a statistical analysis from data on human health in contrast to experimental science conducted under controlled laboratory conditions with detailed knowledge of exposure and breeding or lineage of animals, tissues or cells. Laboratory studies allow greater certainty about cause and effect, but leave major uncertainty about the meaning of the results for exposures experienced by human beings during daily life or work. Epidemiologic studies usually have relatively poor knowledge of exposures that may have occurred over years in a mobile population with diverse genetic composition, health and environmental factors.

Experimental laboratory studies of animals and biological cells and tissues do not support a cause-and-effect connection between these diseases and EMFs of the kind found in the home or near power lines. Although it is possible future research may find a connection, the weight of evidence from animal research indicates to most scientists reviewing the literature that EMFs do not have the effects on animals that, in contrast, are found when examining agents such as x-rays, other ionizing radiation, and chemicals known capable of causing leukemia and other cancers.

The inconsistency between weak findings based on epidemiologic observations and considerable negative findings in laboratory experiments is central to debates in which some contend that weak observational data do not overcome a large set of negative laboratory findings but instead point to weaknesses of epidemiology. However, others see the same observational data as reason for more careful follow up on those results from laboratory research that have shown effects in animals, cells, and tissues, even if obtained under conditions of uncertain relevance to human exposure.

Such conflicts are not unique in the study of health effects for agents other than EMFs. A weight-of-the-evidence approach is often used to assess a body of experimental data that includes conflicting outcomes, varies in scientific quality, and was conducted with various methods in different time periods. Although weighting evidence according to quality, relevance, and consistency also is useful for EMF science, there are considerable difficulties in translating human long-term exposures to variable, weak, environmental EMFs into suitable laboratory exposures with small animals, tissues, and cells.

Inherently, the scientific method does not preclude new findings that will contradict existing conclusions, and similarly it is a matter of logic that science cannot prove with certainty that there are no health effects. Instead, the outcome of the process of scientific inquiry on the potential health hazard of exposure to an environmental factor such as EMFs is a consensus among experts about the likelihood that there is a hazard and the degree of risk, if any.

For that purpose, a number of scientific review panels (some using an explicit weight-of-evidence approach) have been formed by government health or regulatory agencies and by non-government scientific bodies to evaluate the entire body of research on power line EMFs (Table 37). Apart from the 1997 review by a National Academy of Sciences panel that was conducted while the epidemiological evidence was less developed, all have recognized the problem posed by the inconclusive nature of the epidemiological evidence on cancer risk and the relatively small excess risk combined with the absence of an established mechanism that could underlie cancer-causing effects of EMFs. For example, the comprehensive review of biophysical mechanisms by the World Health Organization concluded, “This absence of an identified plausible mechanism does not rule out the possibility of adverse health effects, but it does increase the need for stronger evidence from biology and epidemiology” (WHO 2007). Moreover, the mechanistic problem is deeper than the absence of a suitable mechanism because exhaustive examinations of physical and biophysical mechanisms showed it is highly unlikely that a weak 60-Hz magnetic field could affect any of the pathways known to affect biological matter and cause cancer (Adair 1991; Male 1992; Wood 1993; Weaver et al. 1998; Adair 1999; WHO 2007).

However, most reviewers and panels have been unwilling to dismiss the consistent epidemiologic findings that show a weak association of magnetic fields in the home with childhood leukemia without a stronger explanation for a source of error(s) than is so far available. This reluctance stems from the observation that such errors would have to apply to a number of epidemiology studies conducted in various countries and locales using a variety of study methods (Greenland et al. 2000; Greenland and Kheifets 2006; Pelissari et al. 2009), which seems implausible to some epidemiologists and other reviewers.

Table 34. Key Conclusions from Various Reviews of Potential EMF Health Effects

Key Conclusions	Reference	Note
Epidemiological studies have consistently found that everyday chronic low-intensity (above 0.3– 0.4 µT) power frequency magnetic field exposure is associated with an increased risk of childhood leukemia. IARC has classified such fields as possibly carcinogenic. However, a causal relationship between magnetic fields and childhood leukemia has not been established nor have any other long term effects been established. The absence of established causality means that this effect cannot be addressed in the basic restrictions.	(ICNIRP 2010)	The 2010 report replaces 1998 guidelines. Another report (ICNIRP 2002) gives a general approach (rationales) for health protection for ELF-EMFs and other nonionizing fields.
A consistent pattern of increased risk for childhood leukemia in epidemiological studies is evidence suggesting power frequency magnetic fields are the cause. However, "…virtually all of the laboratory evidence and the mechanistic evidence fail to support a relationship between low-level ELF magnetic fields and changes in biological function or disease status…the evidence is not strong enough to be considered causal but sufficiently strong to remain a concern."	WHO Environmental Health Criteria 238 (World Health Organization 2007)	Comprehensive reviews of many topics on EMF health effects with a glossary of terms.
Magnetic fields were classified as "possibly carcinogenic to humans" based on epidemiological studies.	(IARC 2002)	"Possibly carcinogenic to humans" applies when there is limited evidence of carcinogenicity in humans and less-than-sufficient evidence of carcinogenicity in experimental animals. Gasoline exhaust, styrene, welding fumes, and coffee also are in this category. (WHO 2001).

Indefinite, but considerably persuasive indications that EMFs can cause increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage, with greater confidence EMFs that are not universal carcinogens, do not increase risks of birth defects, or low birth weight and are not likely to increase risks of breast cancer, heart disease, Alzheimer's Disease, depression, or symptoms of EMF sensitivity. Indeterminate conclusions on possibly increased adult leukemia and suicide risks.	California Department of Health Services (DHS) (Neutra et al. 2002)	Atypical presentation of findings in terms of expressions by each of 3 DHS staff scientists on the strength of evidence on numerous research topics. See the report for degrees of confidence expressed by each scientist and for their various conclusions concerning adult leukemia and suicide risks.
Using IARC criteria, the evidence is not strong enough to label ELF-EMF exposure as a known or probable human carcinogen, but a majority of a Working Group concluded that exposure to power line frequency ELF-EMF is a possible carcinogen.	Director and Staff of U.S. National Institute of Environmental Health Sciences (NIEHS 1999)	Mandated report by the NIEHS director to Congress on federally sponsored research (EMF-RAPID program)
"[T]he current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."	(Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems and National Research Council 1997)	Also identified as a National Academy of Sciences report.

Research reviews also have been conducted by individuals or groups independent of government and industry (Cherry 2001; Cherry 2002; BioInitiative Working Group 2012). These reviews typically have interpreted the same scientific literature from an alternative viewpoint that challenges consensus conclusions on EMFs and public health. The most recent such review recommends that "measures should be implemented to guarantee that exposure due to transmission and distribution lines is below an average of about 1 mG" (BioInitiative Working Group 2012), a level more than 1,000 times lower than existing guidelines and standards. Unlike reviews conducted by a panel of interacting, multidisciplinary scientific experts, this report relies on reviews by one or a few authors on a topic or the views of one of the editors, as in the case of the recommendations just cited from the report. Throughout, section titles such as "Evidence For Childhood Cancers (Leukemia)" reflect an approach in which evidence was accrued in support of an EMF health effect in contrast to a weight-of-the-evidence method that generally is used by expert panels. In the papers by N. Cherry, which were not published in the peer-reviewed scientific literature, the author similarly assembled evidence that supported the conclusion that

EMFs cause leukemia in children and adults, among other diseases, but did not use the tools of risk analysis such as a weight-of-the-evidence method. Cherry (2001) concluded, "No level of exposure to artificial oscillating fields is safe," and recommended an exposure limit of 1 mG for adults and 0.2 mG for children. Cherry 2002 presented a generalized mechanism common to electric and magnetic fields across many biological effects, and over vast ranges in field strengths and frequency, although biophysical mechanisms differ greatly with these factors. The conclusions and scientific approaches noted in this paragraph have not been adopted in regulatory decisions on EMFs such as those applicable for this project.

In contrast with the uncertainty surrounding childhood leukemia, neurodegenerative diseases, and possibly a few others, many questions about EMF exposure of humans and animals have, in the view of most scientific panels, been answered conclusively by well-accepted research studies conducted over the past decades. These studies form a large body of evidence from laboratory research and scientific analysis (based on principles of biophysics and biology) that supports the conclusion that EMFs in residential settings and in the environment near transmission lines are not a major public health problem and likely have no adverse health effect on exposed persons. Nonetheless, broad and definitive statements of total certainty concerning health effects cannot be made for EMFs, as often is true for other topics in environmental health.

EMF research also has established the conditions under which very strong EMFs can cause physiological effects and possibly be harmful, including the extreme circumstances where voltages and currents can cause injury and death through electric shocks and burns. All such hazardous effects involve immediate responses to electric currents or voltages in contrast to delayed effects of long-term exposure that are relevant for cancer, neurodegenerative diseases, and chronic health conditions in general.

In addition to science reviews and risk assessments cited in Table 37, others that came to similar conclusions have been conducted by the National Institute for Environmental Health Sciences (USA) (NIEHS 1998), National Radiological Protection Board (McKinlay et al. 2004) (since succeeded by the Health Protection Agency of the UK), Health Canada (Health Canada 2012), and Netherlands Health Council (Health Council of the Netherlands 2008; Health Council of the Netherlands 2009). Conclusions offered by these agencies have authority because their members have the expert knowledge and experience required for balanced, objective, science-based conclusions.

Summary of Weight-of-Evidence Reviews

The conclusions from IARC, ICNIRP, and NIEHS and similar organizations agree that the weight of evidence supports the conclusion that EMFs are not an established cause of adverse health effects, including adult and childhood cancer, Alzheimer's disease, amyotrophic lateral sclerosis, and reproductive effects. Epidemiologic studies of EMF and childhood leukemia (the most common childhood cancer) have been problematic for over three decades. Despite numerous studies and analyses of the body of evidence, it has not been possible to achieve scientific consensus concerning the possibility that the risk of childhood leukemia is greater among the most highly exposed children, who form a small proportion of the total. To date, it has not been possible to determine if the apparent increase in risk is valid or mistaken. Epidemiology studies of EMF exposures in association with other diseases do not have the level of consistency and strength of association that would be convincing evidence of an increased risk, and animal studies failed to show consistent increases in cancer even at high field strengths over lengthy periods. Furthermore, no mechanism has been discovered in laboratory studies or theoretical analyses that explain how electric or magnetic fields at levels found in the environment could cause disease. Given these weaknesses and uncertainties, particularly those derived from epidemiological studies, and because laboratory studies did not support a causal relationship, IARC and NIEHS assigned EMF to the lowest category of cancer risk as a "possible carcinogen."

The only studies that demonstrate a definite relationship between electric and magnetic fields and an adverse biological or health effect are those in which very high levels of exposure to these fields produce currents and fields in the body at levels approaching a very weak electric shock. These short-term effects occur only with very high field strengths that exceed exposure guidelines designed to protect against their occurrence. Fields at these high intensities are not found in residential environments near transmission lines or elsewhere where the public has access.

Electric Field Effects, Spark Discharges, and Electric Shock

Computer-based models allow calculation of electrical exposures to the body's outer surface, internal tissues and organs. The relatively good electrical conductance of body tissues acts to reduce external field strengths by a factor of 100,000 to 1 million or more, which indicates that the more appropriate measure of internal exposure is the density of electric current, not electric field strength in the body. Determining exposure to electric fields for human beings and laboratory animals requires understanding a number of variables, including the external electric field at the body surface, the quality of a connection to ground if present (for example, through feet and shoes), and the body's size, height and surface area.

Strong electric fields in the vicinity of some power lines, for example, above about 5 to 10 kV/m, can cause phenomena similar to the static electricity experienced indoors on a dry winter day, or with certain clothing fabrics just removed from a clothes dryer. As a result, there can be nuisance electric discharges when a person touches ungrounded long metal fences, pipes, or large vehicles (for example, buses) near a power line of sufficiently high voltage (usually several times greater than 120 kV). These phenomena, also called micro-shocks or spark discharges, generally are not observed for power lines operating below several hundred kilovolts. Although potentially annoying and capable of startling a person, these discharges are not in themselves harmful.

In contrast to micro-shocks, high voltage power lines pose a severe electric shock hazard if a conducting object gets close enough to the energized conductors to cause an electric arc ("flashover"). For a person or animal, contact with energized conductors (or a conducting object experiencing flashover) and the very high current densities occurring with electric shock can cause stimulation of nerves and muscles, tissue heating, and at extreme levels, serious or fatal effects due to cardiac arrest and electrical burns.

Effects of EMFs on Biota and Ecological Relationships

Research has been conducted to assess potential EMF effects on agricultural crops, soil, birds, mammals, reptiles, insects and ecological communities such as forests, aquatic and marine environments (Lee, Jr. 1996). Some areas have been intensively studied, but others pose myriad challenges that have not yet been subjected to substantial investigation (ICNIRP 2000). Among the topics researched intensively are honeybee colonies, which can be adversely affected by micro-shocks that can occur at 60-Hz electric field strengths greater than 4.1 kV/m (Greenberg et al. 1981; Bindokas et al. 1988), and the biological phenomena of electro-sensitivity in aquatic and marine animals (Murray 1965; von der Emde 1999; Peters et al. 2007) that were studied without specific application to 60-Hz power line EMFs. The U.S. Navy conducted a long-term ecological research program on EMFs that were similar to power line fields (Zapotosky et al. 1996). A program review found “no evidence of statistically significant, widespread, adverse effects of EMFs” on numerous ecological parameters, although some research was not conclusive concerning small effects due to study deficiencies (NRC and Committee to Evaluate the US Navy's Extremely Low Frequency Communications System Ecological Monitoring Program 1997 p 8). Sheppard (2000) reviewed ecological considerations for power line projects, including additional features of the areas mentioned above and topics in wildlife biology and agriculture with the conclusion that only effects on honeybee colonies are a demonstrated adverse effect of power line exposures. However, ecological relationships are many and complex, leaving many knowledge gaps that should be filled before stronger conclusions about ecological effects of high voltage power lines can be made.

Effects on Livestock and Farm Animals

A public comment on the project referred to a news report (Oberbeck 2012a; Oberbeck 2012b) about unusual deaths of cows due to “stray electricity” from a power plant in Utah. “Stray electricity” is not a term used in the technical literature on EMF, and appears in context of the article to be an expression of concern about unidentified influences with a source at a Utah electricity generating plant. The term resembles “stray voltage,” which is discussed below, but there is no technical or scientific relationship between the terms and any underlying phenomena.

The potential effects of power frequency transmission line EMFs have been the subject of considerable research and are of interest for this project where large animals may be exposed on rangeland or private ranch property, although no dairy or cattle operations are identified within 0.5 mi of the project and alternative routes. Large four-legged animals such as cattle, bison, horses, swine, and sheep are exposed to EMFs in grazing or pasture lands with power lines, and in barns and pens. The areas of interest and economic importance that have been studied most intensively are dairy cow productivity (milk production), a sensitive indicator of overall health, reproductive success, morbidity and mortality, weight gain, and health indicators from veterinary treatment records. In addition, the biophysics of electric stimulation and health effects due to contact currents and field exposure have been subjects of engineering and academic research. Four-legged animals pose a somewhat different electrical exposure problem than in research on human beings because their four points of contact with the ground are more widely separated than for bipeds (human beings) and in view of their greater size (Kaune and Phillips 1980). Principal findings in these areas are highlighted below.

Lee (1996) provided a concise review of a number of studies with long-term exposures of livestock long to 50- or 60-Hz transmission line electric and magnetic fields. Results from a number of controlled, long-term studies on milk production, animal health, reproductive success, behavior, growth and immune system function were consistent in finding no effects for several species, with most studies showing no influence of the transmission line and in a few other cases possible effects which were not confirmed in follow-up studies. Reinemann (2005) provided an overview of an extensive part of the literature on electrical and magnetic influences, including stray voltages, on farm animals. He included dairy cattle, beef cattle, sheep, horses, poultry and others species in an extensive annotated critical bibliography.

Stray Voltage

This term refers to circumstances where a person or animal can be in contact with two objects that have a voltage difference of several volts due to the electrical installation. Unintended currents can flow in the soil or metallic objects due to inadequate or improper installation or failed maintenance of metallic wiring that should carry those currents (for engineering details, see Lefcourt, A.M. (ed.) 1991). The concern for stray voltage has often arisen on dairy farms and livestock operations where questions of milk production, animal health, growth and reproduction have come to attention and stray voltage was a suspected cause. Electric current (i.e., “stray current”) is the appropriate quantity for measuring exposures to an animal, whether at high levels (electric shock) or to evaluate potential physiological and behavioral effects, but for practical reasons, voltage is the feature commonly measured and specified in exposure recommendations for stray voltage. For a given voltage, the amount of current conducted through an animal is determined by the body impedance (Ohm’s Law). An authoritative Department of Agriculture handbook (Lefcourt, A.M. (ed.) 1991) recommended that a voltage of 2 to 4 V between two objects that can be contacted at the same time is excessive and should be reduced. Cows rarely show detection below 0.5 to 1 V, a level where mitigation is unneeded. This voltage range corresponds to observations consistent with threshold currents of about 3 to 6 mA. The physiology and biophysics of electrical stimulation of nervous system tissues has thoroughly studied and comprehensively reviewed by Reilly (1998) including responses of dairy cows to 60-Hz electric currents and magnetic fields. The extensive literature on stray voltage in dairy farming was examined from data in 22 studies using meta-analysis and pooling of data (Erdreich et al. 2009). The authors found that 3.0 mA was the average threshold for behavioral effects and for observable effects on milk production.

Assessment of Potential Health Impacts from the Proposed Project

Calculated magnetic fields for each route segment of each of the project alternatives are characterized with respect to existing standards and guidelines for EMF exposure and the potential for health impacts. Electric fields for all levels that would exist in the project area are within standards and guidelines, and consistent with expert opinion that research showed no cancer-causing effects of electric field exposures (NIEHS 1999; IEEE 2002; IARC 2002).

Appendix A provides assessment tables of potential health impacts from the proposed project and routing alternatives.

North Virginia Street Residences

Two residences on North Virginia Street are within approximately 65 feet of the future route for the proposed C2B 120 kV transmission line with underbuilt 25 kV distribution line #257, and with the existing Alturas 345 kV line across North Virginia Street. The measured magnetic field strengths at 120 feet from the existing 345 kV line (60 feet from the proposed C2B line) were 1.7 mG (Table 20). Calculations for the Poeville alternative (route 5) show that along North Virginia Street (segment 19) at 60 feet from proposed C2B/#257 line, magnetic fields would be no greater than 2.8, 3.9, and 9.7 mG for light, medium, and maximum loadings, respectively. At all those magnetic field levels, magnetic fields at the front of the residence would be fully compliant with standards and guidelines, indicating no health impacts through established EMF effects. For comparison, these magnetic field levels can be compared to data cited above for US average residential magnetic fields (0.9 mG), average 24-hour U.S. personal exposure (1.25 mG), and residential distributions (Table 3), which show that the existing and proposed future maximum magnetic fields outside of the right-of-way of the C2B/#257 and Alturas power lines are likely to exceed average U.S. residential levels. However, average residential magnetic field levels are well below the ACGIH occupational threshold level for workers with implanted medical devices (1,000 mG) identified for this study and are within the Minor magnitude classification shown in Table 32 (< 250 mG). It is important to note that the calculated magnetic fields are the maximum values that would occur for minimum height of the conductors (which occurs mid-span) and projected line loading, and to note that the magnetic field strength decreases approximately with the square of distance to the power line.

Similar considerations apply to several residences in segments 20, 21, and 22 that are along Trail Drive, Mar Mac Way and as close as 75 feet to the proposed C2B power line. Other residences within 0.5 mile from the C2B project are too far away to incur changes that are significant with respect to average U.S. residential magnetic fields and similar benchmarks.

Verdi School, Library, and Nearby Residences

Calculations for segment 27 that is common to the Poeville, Stateline/Poeville and Peavine/Poeville alternatives (routes 5, 6, 7) are of interest for a number of residences near Lakeview Drive, the Verdi Community Library, and Verdi Elementary School. Calculations for the Verdi Elementary School property show that magnetic fields at the building closer to the C2B line (approximately 410 feet distant) would be approximately 0.9, 1.3, and 1.6 mG for light, medium, and maximum loading conditions. The second school building is approximately 110 feet further away and calculated maximum magnetic fields at the side closest to C2B would be 0.6, 0.8, and 1.0 mG. At all those levels, magnetic fields at the school buildings would be fully compliant with standards and guidelines, indicating no health impacts through established EMF effects. For comparison, these magnetic field levels can be compared to data cited above for US average residential magnetic fields (0.9 mG), average 24-h U.S. personal exposure (1.25 mG), and related distributions (Tables 3 and 4). These comparisons show that the existing and proposed future maximum magnetic fields closest to the C2B power line might be higher than average residential levels, but within the range of many residences in the U.S. It is important to note that the calculated magnetic fields are the maximum values that would occur for minimum height of the conductors (which occurs mid-span) and projected line loading, where the magnetic field decreases approximately with the square of distance to the power line. Actual school building magnetic fields due to the C2B transmission line could be lower. The calculated magnetic fields do not, of course, reflect possible sources within the buildings.

The Verdi Community Library building is approximately 70 feet from centerline of existing line #632 that would be the future location of C2B, and approximately 20 feet from the right-of-way. Calculations show that magnetic fields at the building side closer to the C2B line (approximately 70 feet away) would be no greater than 12.9, 18.4 and 23.9 mG for light, medium, and maximum loadings. These levels can be compared to data for U.S. residences (Table 3) and U.S. personal exposure (Table 4) to show that the existing and proposed future maximum magnetic fields closest to the C2B power line are likely to exceed most U.S. residential levels. However, average residential magnetic field levels are well below the ACGIH occupational threshold level for workers with implanted medical devices (1,000 mG) identified for this study and are within the Minor magnitude classification shown in Table 32 (< 250 mG). It is important to note that the calculated magnetic fields are the maximum values that would occur for minimum height of the conductors (which occurs mid-span) and projected line loading, where the magnetic field decreases approximately with the square of distance to the power line. Actual library building magnetic fields due to the C2B and other nearby transmission lines could be lower. The calculated magnetic fields do not, of course, reflect possible sources within the building.

Certain residences near where the C2B line would cross the Truckee River along Lakeview Dr. and adjoining streets are at distances to the project of approximately 50 to 150 feet. Calculated maximum magnetic field strengths at such distances are in the ranges of 3.3 to 22.9 mG, 4.7 to 32.6 mG, and 6.0 to 42.9 mG at 50 to 150 feet, for light, medium and maximum loadings, respectively. These levels indicate that various locations are likely to experience magnetic field levels above the U.S. residential average and U.S. 24-h average exposure. The considerations cited above for conductor height, line loading, distance from the power line, and interior sources of magnetic fields also apply in this area.

Stray Voltage/Current

The proposed C2B project would not create conditions where stray current or stray voltage is likely to occur.

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Appendix A

Assessment of Potential Health Impacts from EMFs of the Proposed Project Alternatives

The routing of alternative 2, “Stateline Alternative,” requires five configurations for the 120 kV C2B line and other existing lines along the route. Table A-1 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-1. Assessment of Potential Health Impacts of Magnetic Fields for the Stateline Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG)			Characterization of Exposure and Potential Health Impacts
		Light	Medium	Maximum	
1, 2	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	[a] Fully compliant with standards/guidelines, indicating no health impacts through established EMF effects. No residences within approx. 0.4 mile; no significant effect with respect to average U.S. residential magnetic field exposures.
3, 4, 5, 6	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guidelines, indicating no health impacts through established EMF effects. No residences within approx. 0.5 mile (segments 3, 4, 5) and none within 0.25 mile (segment 6); no significant effect with respect to average U.S. residential magnetic field exposures.
7	C2B, #102 [4]	10.4/20.8	15.6/29.6	15.3/40.8	[a] Fully compliant with standards/guidelines, indicating no health impacts through established EMF effects. No residences within approx. 0.25 mile; no significant effect with respect to average U.S. residential magnetic field exposure.
8	C2B, #204 with underbuild [5]	14.0/13.3	20.3/19.2	28.1/26.6	[a] Fully compliant with standards/guidelines, indicating no health impacts through established EMF effects. No residences within approx. 275 feet; no significant effect with respect to average U.S. residential magnetic field exposures based on calculations at 100 feet from the C2B centerline.
9	C2B, 25kV underbuild [2]	13.2/13.9	18.9/19.9	26.0/27.6	[a] Fully compliant with standards/guidelines, indicating no health impacts through established EMF effects. One residence within 500 ft. of project C2B line; no anticipated significant effect with respect to average U.S. residential magnetic field exposures based on calculations extended to 100 feet of project C2B centerline.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

The routing of alternative 3, "Mitchell Alternative" requires five configurations for the 120 kV line and other lines along the route. Table A-2 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-2. Assessment of Potential Health Impacts of Magnetic Fields for the Mitchell Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG)			Characterization of Exposure and Potential Health Impacts
		Light	Medium	Maximum	
1, 2	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 0.4 mile; no significant effect with respect to average U.S. residential magnetic field exposures.
3, 10	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. One residence, located in Calif. (segment 3) approx. 500 feet W; no effect on residential magnetic field with respect to average U.S. residential magnetic field exposures.
11, 7	C2B, #102 [4]	10.4/20.8	15.6/29.6	15.3/40.8	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.2 mile; no significant effect with respect to average U.S. residential magnetic field exposure.
8	C2B, #204 with underbuild [5]	14.0/13.3	20.3/19.2	28.1/26.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 275 feet; no significant effect with respect to average U.S. residential magnetic field exposures based on calculations at 100 feet from the C2B centerline.
9	C2B, 25kV underbuild [2]	13.2/13.9	18.9/19.9	26.0/27.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. One residence within 500 ft. of project C2B line; no anticipated significant effect with respect to average U.S. residential magnetic field exposures based on calculations extended to 100 feet of project C2B centerline.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

The routing of alternative 4, “Peavine Alternative,” requires five configurations for the 120 kV line and other lines along the route. Table A-3 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-3. Assessment of Potential Health Impacts of Magnetic Fields for the Peavine Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG) Light	Medium	Maximum	Characterization of Exposure and Potential Health Impacts
1, 2, 12	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.5 mi (segments 1, 2, 12); no effect with respect to average U.S. residential magnetic field exposures.
6, 13, 14	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approximately 0.25 mi of the C2B; no effect with respect to average U.S. residential magnetic field exposures.
7	C2B, #102 [4]	10.4/20.8	15.6/29.6	15.3/40.8	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.2 mile; no significant effect with respect to average U.S. residential magnetic field exposure.
8	C2B, #204 with underbuild [5]	14.0/13.3	20.3/19.2	28.1/26.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 275 feet; no significant effect with respect to average U.S. residential magnetic field exposures based on calculations at 100 feet from the C2B centerline.
9	C2B, 25kV underbuild [2]	13.2/13.9	18.9/19.9	26.0/27.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. One residence within 500 ft. of project C2B line; no anticipated significant effect with respect to average U.S. residential magnetic field exposures based on calculations extended to 100 feet of project C2B centerline.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

The routing of alternative 5, “Poeville Alternative,” requires five configurations for the 120 kV line and other lines along the route with further subdivision for the two options for location of the C2B line for segment 19 along North Virginia Street. Table A-4 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-4. Assessment of Potential Health Impacts of Magnetic Fields for the Poeville Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG)			Characterization of Exposure and Potential Health Impacts
		Light	Medium	Maximum	
1, 2, 12, 17, 18,	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.5 mi (segments 1, 2, 12, 17); two residences (segment 18) >650 feet from C2B project route; no effect with respect to average U.S. residential magnetic field exposures.
25, 26	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.5 mi (segment 25); closest residences south of highway 80 and south of the bend at segments 26 and 27 are > 1500 feet away; no effect with respect to average U.S. residential magnetic field exposures.
27	C2B, #114, /#106, /#632† [6]	11.9/22.9	16.9/32.6	14.9/42.9	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Existing ROW and project C2B abut Verdi Community Library: nearest side approx. 70 feet from centerline of existing line #632 (future location of C2B). Verdi Elementary School buildings approx. 310 feet and 420 feet SE of this centerline. Several residences or structures near crossing of Truckee R. are at distances to the project of approx. 50 feet to 150 feet. Calculations for maximum magnetic field strength at Medium and Maximum load indicate possible noticeable increases above U.S. average residential magnetic fields; significant increases are possible within approx. 250 feet and less. Actual increases depend on line load and line height above ground at site of interest (and related to H-frame location) and would be less than maximums.

19 – Option 1, 368 feet from Alturas 345 kV line	C2B on pole, 25 kV underbuild [7-option 1]	14.1/13.4	20.1/19.1	27.5/26.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Residential magnetic fields may increase significantly with respect to average U.S. residential magnetic field exposures, depending on nearby span height, line load, and distance to C2B. Other residences within 0.5 mile are too far from the C2B project to expect increases significant with respect to average U.S. residential magnetic fields.
19 – Option 2, 60 feet from Alturas 345 kV line	C2B on pole, 25 kV underbuild [7-option 2]	21.5/12.3	31.1/17.6	25.3/26.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Two residences are within approx. 65 feet of the C2B/#257 route along N. Virginia St.; residential magnetic fields may increase significantly with respect to average U.S. residential magnetic field exposures, depending on nearby span height, line load, and distance to C2B. Other residences within 0.5 mile are too far from the C2B project to expect increases significant with respect to average U.S. residential magnetic fields.
20, 21, 22, 23, 24	C2B, 25kV underbuild [2]	13.2/13.9	18.9/19.9	26.0/27.6	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Two residences (segment 19) are within approx. 65 feet of C2B/#257 route along N. Virginia St.; several residences in segments 20, 21, and 22, (especially along Trail Dr.) are as close as 75 feet of the mapped C2B centerline; at all these sites, residential magnetic fields may increase significantly with respect to average U.S. residential magnetic field exposures, depending on nearby span height, line load, and distance to C2B (calculations to 100 feet from C2B centerline). Other residences within 0.5 mile are too far from the C2B project to expect increases significant with respect to average U.S. residential magnetic fields.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

[†] Line #632 not in service and excluded from analysis

Route 6 “Stateline/Poeville Alternative” requires three configurations for the 120 kV line and other lines along the route. Table A-5 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-5. Assessment of Potential Health Impacts of Magnetic Fields for the Stateline/Poeville Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG)			Characterization of Exposure and Potential Health Impacts
		Light	Medium	Maximum	
1, 2	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 0.4 mile; no effect with respect to average U.S. residential magnetic field exposures.
3, 4, 15, 16, 26	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 0.5 mile (segments 3, 4, 15, 16) and none within 0.25 mile (segment 26); no significant effect with respect to average U.S. residential magnetic field exposures.
27	C2B, #114, /#106, /#632† [6]	11.9/22.9	16.9/32.6	14.9/42.9	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Existing ROW and project C2B abut Verdi Community Library: nearest side approx. 70 feet from centerline of existing line #632 (future location of C2B). Verdi Elementary School buildings approx. 310 feet and 420 feet SE of this centerline. Several residences or structures near crossing of Truckee R. are at distances to the project of approx. 50 feet to 150 feet. Calculations for maximum magnetic field strength at Medium and Maximum load indicate possible noticeable increases above U.S. average residential magnetic fields; significant increases are possible at approx. 250 feet and less. Actual increases depend on line load and line height above ground at site of interest (related to H-frame location) and would be less than maximums.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

† Line #632 not in service and excluded from analysis.

Route 7 “Peavine/Poeville Alternative” requires three configurations for the 120 kV line and other lines along the route. Table A-6 shows the maximum calculated magnetic fields for various load conditions and characterizes each with respect to the potential for health effects.

Table A-6. Assessment of Potential Health Impacts of Magnetic Fields for the Peavine/Poeville Alternative Under Light, Medium, and Maximum Loads

Segment	Configuration [Case]	Calculated Magnetic Field at Left/Right Edges of ROW* (mG)			Characterization of Exposure and Potential Health Impacts
		Light	Medium	Maximum	
1, 2 , 12	C2B, Alturas 345kV [3]	22.1/22.0	31.5/31.4	41.8/41.8	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within approx. 0.4 mile; no effect with respect to average U.S. residential magnetic field exposures.
13, 16, 26	C2B [1]	21.5/21.5	30.7/30.7	42.0/42.0	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. No residences within 0.5 mile (segments 13, 16) and none within 0.25 mile (segment 26); no effect with respect to average U.S. residential magnetic field exposures.
27	C2B, #114, /#106, /#632† [6]	11.9/22.9	16.9/32.6	14.9/42.9	[a] Fully compliant with standards/guide-lines, indicating no health impacts through established EMF effects. Existing ROW and project C2B abut Verdi Community Library: nearest side approx. 70 feet from centerline of existing line #632 (future location of C2B). Verdi Elementary School buildings approx. 310 feet and 420 feet SE of this centerline. Several residences or structures near crossing of Truckee R. are at distances to the project of approx. 50 feet to 150 feet. Calculations for maximum magnetic field strength at Medium and Maximum load indicate possible noticeable increases above U.S. average residential magnetic fields; significant increases are possible at approx. 250 feet and less. Actual increases depend on line load and line height above ground at site of interest (related to H-frame location) and would be less than maximums.

***** Maximum calculated for minimum ground clearance at mid-span; magnetic field strengths elsewhere along the line are lower. Left and right correspond to line arrangements, and compass directions (where given) for cases 1-7 (Figs. 19-33).

[a] All magnetic fields at any edge of ROW are less than 5% of ICNIRP and ICES guidelines for general public exposures and ACGIH guidelines for workers with implanted medical devices. Field strengths decrease with distance and are approximately one-fourth as strong with each doubling of distance from the power line.

† Line #632 not in service and excluded from analysis.